BBC

#### WHAT'S HAPPENING TO THE WEATHER? Why the jet stream is to blame and why summers are about to get hotter



Hawking's black holes

Cosmologist's latest theory explained

Noah's ark

Is there any truth to the Bible story?

Chocolate: it's good for you!

Health facts revealed

ISSUE 267 / MAY 2014 / £3.99

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INSIDE THE LABS ON THE BRINK OF LIMITLESS ENERGY

that will shape the future

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## WELCOME



HOW MUCH ENERGY does the Sun produce? To think about it, imagine a bridge of ice 3km wide and 2km thick. extending from the Earth to the Sun. The Sun could melt all of it in one second. Recreating this awesome power would solve our energy problems overnight, so it's no surprise that the race is on to build a working fusion reactor. We reveal the top contenders on p34.

Here on Earth, the weather seems to be getting more extreme than ever, from North America's polar vortex to the floods in the UK. Is the jet stream at fault, and will it

continue? Paul Simons finds out on p72. Talking of floods, this month sees the release of Noah starring Russell Crowe as the eponymous biblical hero. But did he really exist and did he build an ark? We spoke to the British Museum's Irving Finkel to get some answers (see p54).

From the Old Testament to the New, it's Easter this month and the chances are that you'll be indulging in a chocolate egg (or two). But don't feel too bad turn to p52 for some surprising health advice, and enjoy your treats.

Finally, I'm delighted to welcome BBC Science Editor David Shukman as our brand new columnist. A familiar face from BBC News, David will bring you his insights every month in our Discoveries section.

Until next issue,



Graham Southorn, Editor

P.S.

Don't miss our June issue. on sale 1 May 2014



**AVAILABLE ON YOUR DEVICE NOW!** 

#### THIS MONTH WE...



...worked from home using telepresence devices. Did we get any work done, or did we just annoy people in our office? Turn to p84 for our reviews of four mobile avatars.

...went to the recording of Radio 4's It Is Rocket **Science!** starring Helen Keen, Peter Serafinowicz and Susy Kane. And laughed... a lot. We talk to Helen about the show on this month's podcast.





...spoke to Leonard Susskind, the leading theoretical physicist, about that most enigmatic of topics: the quantum world. You'll find the interview on our podcast this month.

#### CONTACTS

- ADVERTISING steve.grigg@immediate.co.uk 0117 314 8750
- FOR PUBLICATION reply@sciencefocus.com
- EDITORIAL ENQUIRIES editorialenquiries@sciencefocus.com 0117 314 7388
- SUBSCRIPTIONS/BACK ISSUES focus@servicehelpline.co.uk 0844 844 0260\*
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#### APPEARING IN THIS ISSUE



Lilian **Anekwe** 

Lilian is consumer health editor for the weekly journal BMJ.

With Easter fast approaching, who better to investigate the health benefits of our national addiction: chocolate?



**Brian** Clegg

Brian is the author of popular science titles including A Brief History

Of Infinity and Build Your Own Time Machine. This issue he tackles the search for science's Holy Grail: nuclear fusion.



Irving **Finkel** 

Dr Finkel is a curator at the British Museum in charge of 'cuneiform'

inscriptions on ancient stone tablets. One of these tells the true story of Noah's Ark, as he reveals on p54.



David **Shukman** 

The BBC Science Editor joins Focus this month as a regular

columnist in our Discoveries section. This month he reflects on the recent floods and how science can help.





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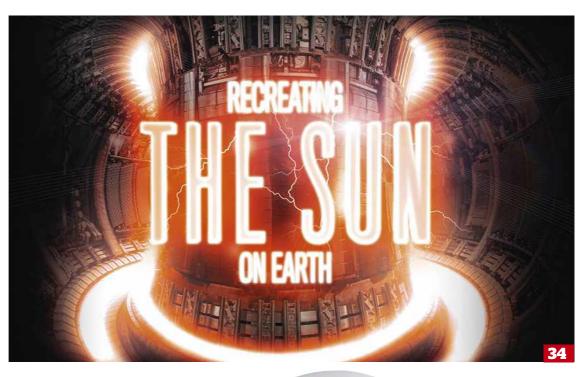
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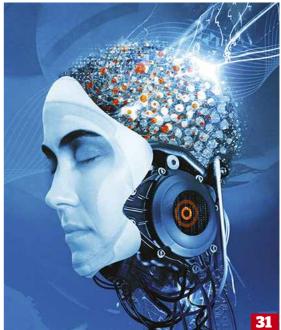
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Awe-inspiring images from the world of science

## MegaPixel









#### Cyberfish

THIS CRITTER'S SPOOKY appearance may bring to mind the sinister Cybermen, *Doctor Who*'s automaton adversaries, but fear not, it is actually a harmless zebrafish embryo. And at only four days old and 1.4mm long, it's unlikely to harbour any plans of taking over the human race.

In fact, zebrafish embryos are fantastically helpful tools for

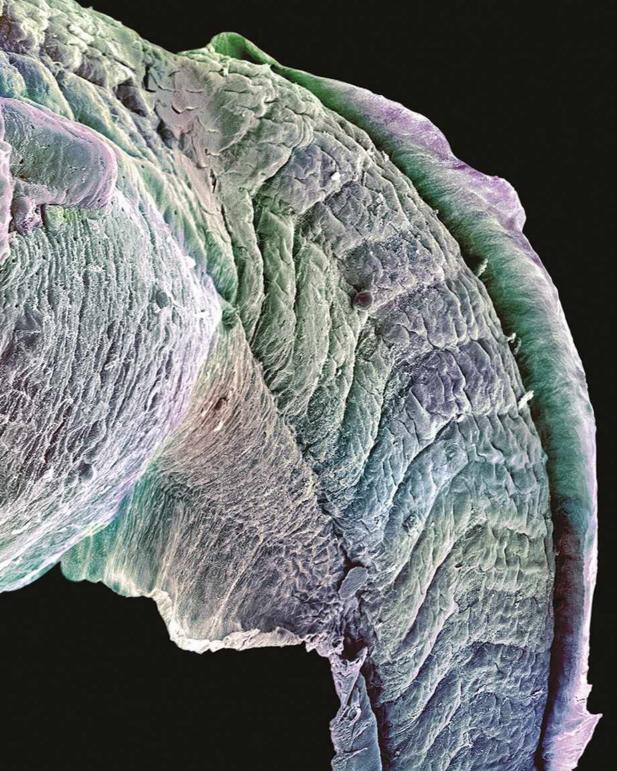
biomedical scientists. They are inexpensive, easy to manipulate genetically, and develop quickly.

"The zebrafish started out as a favourite among developmental biologists, but it is becoming ever more popular in genetics and neuroscience labs," says Annie Cavanagh of the UCL School of Pharmacy, who helped prepare this picture. "They are also used

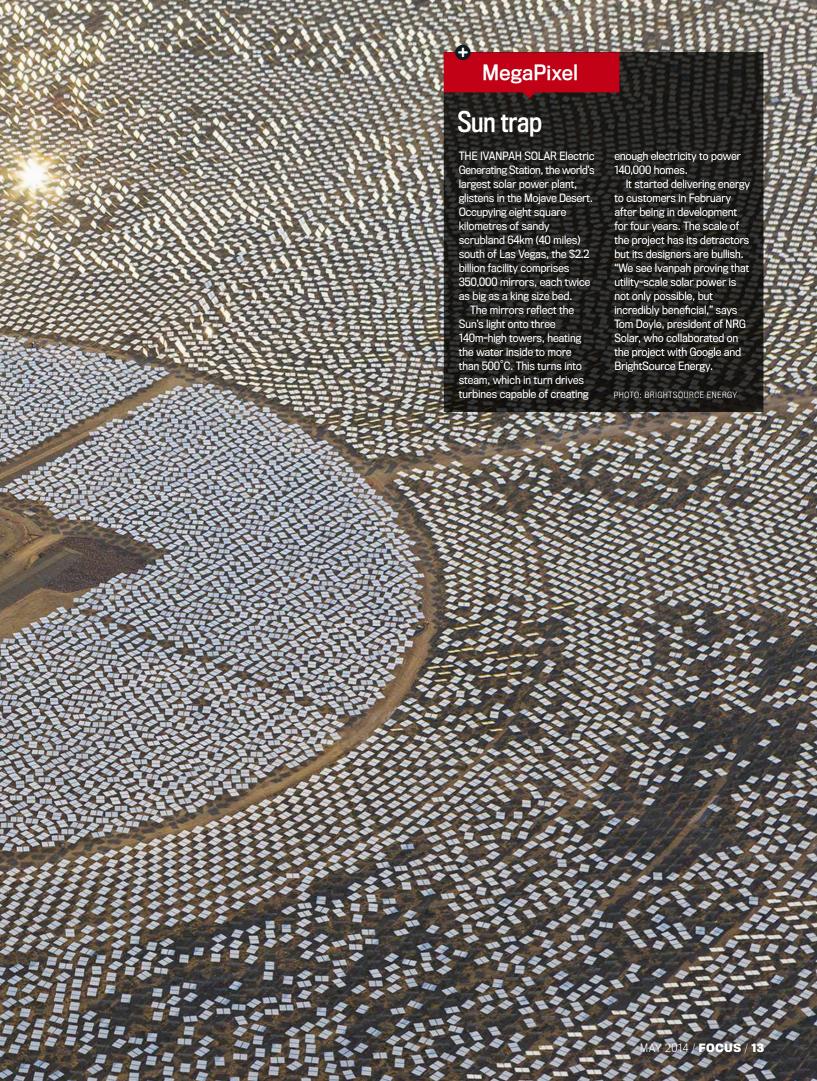
as a valuable tool for cancer research, since zebrafish have been found to develop almost any human tumour type."

So, far from being a threat to world civilisation, these miniscule water creatures actually assist us in tackling some of the greatest horrors facing mankind.

PHOTO: ANNIE CAVANAGH/ WELLCOME TRUST







## REPLY

Your opinions on science, technology and BBC Focus Magazine

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Letters may be edited for publication



#### Medicine's quantum leap

I READ WITH great hope the article in the April issue (p21) concerning stem cells. The ability to generate cells having the ability to transform into any other cell in the body would surely rate as one of the quantum leaps in medicine.

This particular means of obtaining such cells without the controversial use of human embryos will also eliminate two other major problems: one moral, the other practical. If the initial cells are taken from the person they are to be grown on and then used, there can be no qualms on ethical or religious grounds. The second advantage is that we're never going to get enough suitable donors for transplants.

I know that there is an enormous difference between mice and humans and that it will take a considerable time before the research leads to a viable form of treatment. However, I hope that the little green mouse is truly a signal that the scientific road ahead is passable.

#### **David Storer, Totton**

Since we went to press, an investigation into this study has been launched. A statement from RIKEN said, 'It is extremely regrettable that significant discrepancies have been found to have been generated in the process of preparing the articles for publication.' We'll keep you up to date as this story develops. – **Ed** 

## Write in and win! The writer of next issue's Message of the Month wins a Netgear PTV3000 Wireless Display Adapter, worth £79.99. It uses Wi-Fi to mirror the display of compatible smartphones, tablets and laptops on your high-definition TV. See http://bit.ly/lcoRvFZ for details and visit www.netgear.co.uk

#### Space research slammed

It is not the first time we've come across an article relating to finding life on Earth-like planets (January, p22), and we wonder if it's appropriate to carry out such research as it's pretty uncertain and there is no practical use – you cannot reach those planets. The time and money could be invested in more useful research, for example investigating the ozone layer.

Anastasia Nekrasova and Gabriela Prestes, Montevideo, Uruguay

Space research creates jobs on Earth and trains young scientists, some of whom go on to succeed in business, creating wealth and more jobs. There are practical spinoffs too. The first digital cameras were developed for surveillance satellites, and new techniques for sifting through large amounts of data could be useful for future search engines. – **Ed** 

#### Chip off the old block

I presume it is the angle of the photograph that makes the 1 million-year-old stone tool on p66 of the March issue look like a carving of the face of a sleeping man? And, further to the 'psychology of astrology' suggestion in *Reply*, it is obvious that until recent times, a foetus carried in the winter months enjoyed quite different nutrition to one whose mother was eating the leaves and fruits of summer. This might well have had an effect on physical and brain development.

Lynn Moore, Northampton

#### **Astrology blurs the lines**

Having read Chris MacLennan's letter in the January edition about astrology, I wanted to reply. In newspapers, both tabloid and sometimes broadsheet ones, astrology gets featured far more heavily than any science story, astronomy or otherwise. Surely it's not right that some children believe astrology more than astronomy. The line between fact and fiction, in my opinion, is becoming increasingly blurred.

**Claire Nicholson** 

#### **Scottish hum**

The article on p96 of February's issue identified locations around the world where a mystery hum has been heard, similar to the hum that some residents in this small Scottish west coast village experience. In 1977 an article published in a newspaper received 800 responses by people bothered by the noise. Research has been ongoing for the past 10 years but has reached no obvious conclusion as to what might be generating such a low power noise, which can be heard both inside and outside houses, day and night. The reasons suggested are similar to those in your article.

Roger Evans, Argyll

#### No robots please

The humanoid robot on the cover of your March issue is surely an unnecessary monstrosity created to illustrate the cleverness of the modern scientist. Why try to emulate human intelligence when the latter is infinitely complicated? It's certainly a complete waste of time.

**Kym Temby, St Ives** 

#### **Smart foxes**

One notable omission from your article on animal intelligence ('How Smart Are Dolphins?', February, p52) surely has to be the urban fox. Where I live, they can open a locked food bin and make off with the contents in under two minutes.

**Terry Fairhall, Chessington** 



#### Sun survival

While reading your March issue I was intrigued to discover that the Sun is losing 4.26 million tonnes of mass every second due to fusion! The figures seem to indicate that we don't have much time left: a little under two months!

Joshua Wall

Well spotted. By the end of the Sun's life, it will have lost 0.034% of its mass as we said. But we should have said that the Sun loses 7x10<sup>-15</sup>% of its mass, per year. - Ed

#### YOUR COMMENTS ON **OUR FORUM**

At http://sciencefocus.com/forum/, members discussed our article on Robert Lanza's theory (February, p21)

Thinker: Focus mentioned Robert Lanza's Biocentric Theory. His idea is that the Universe is a product of our consciousness of it. With no one to view the Universe, it ceases to be. I see several issues here. Firstly it's resurrecting this stupid idea that humans are the centre of the Universe. Secondly, we're a product of the Universe, which allows us to observe it. I can't believe his theory can be classed as science.

Lateralman: If a tree falls in a forest and no one is around to hear it. does it make a sound?

MikeG: I wonder what the chances are of consciousness existing in other forms? That is, without being tied to a biological entity. After all, our own consciousness is nothing more than a conglomeration of chemicals and amino acids. With a Universe as old as 15 billion years, perhaps something, somewhere, has evolved that doesn't need a biological process to be self-aware.

M Paul Lloyd: Even if humans had never existed, the Universe would continue in its course. Chances are that a few other sentient races are out there somewhere.

Thinker: How does he [Lanza] explain the fact that when we look at galaxies millions of light-years away we're looking back in time, long before humans or even animals existed on Earth? If the Universe only exists because of how we view it, then the early stars we view shouldn't be there.

M Paul Lloyd: Our brains are capable of all sorts of wonderful things, but given that each person's consciousness is in effect unique, then every person's imagined Universe would surely differ from everyone else's.

Join the discussion at http://sciencefocus.com/forum/

#### Oops!

• In April issue's Patently Obvious we printed two numbers (US 20140025620) and GB2504665) for designs that are patent applications. To clarify, the patents have not yet been granted.

#### EDITORIAL

ditor Graham Southorn Daniel Down Reviews Editor Daniel Bennett Commissioning Editor Jason Goodyer Editorial Assistant James Lloyd Science Consultant Robert Matthews Contributing Editor Emma Bayley

#### **ART & PICTURES**

Art Editor Joe Eden Designer Jon Rich Picture Editor James Cutmore

#### CONTRIBUTORS

Lilian Anekwe, Joseph Barnes, Stephen Baxter, Susan Blackmore, Christopher Brennan, Dean Burnett, Helen Cahill, Marcus Chown, Brian Clegg, Helen Czerski, Elaine Fox, Dale Edwin Murray, Alastair Gunn, Timandra Harkness, Adam Howling, Gerry Leblique, Cherry Lewis, Justin Metz, Gareth Mitchell, Kelly Oakes, Iheni Osman, Fred Pearce, Ciara Phelan, Helen Pilcher, Andy Potts, Press Association, Paul Simons, Giles Sparrow, Peter Strain, Secret Studio, Joe Svetlik, Bill Thompson, Magic Torch, Jan Van Der Veken, Luis Villazon, Paul Weston

#### ADVERTISING & MARKETING

dvertising Director Caroline Herbert Advertising Manager Steve Grigg Deputy Advertising Manager Marc Gonzalez Brand Sales Executive James Young ive Carl Kill Newstrade Manager Rob Brock Subscriptions Director Jacky Perales-Morris Direct Marketing Manager Mark Summerton

aurence Robertson 00353 876 902208

#### LICENSING & SYNDICATION

International Partners Manager Anna Brown

Press Officer Carolyn Wray

#### **PRODUCTION**

Production Director Sarah Powell Production Coordinator Emily Mounter Paul Thornton Ad Coordinator Jade O'Halloran Ad Designer Matt Gynn

#### PUBLISHING

ublisher Andrew Davies Chairman Stephen Alexander icer Tom Bureau Deputy Chairman Peter Phippen Managing Director Andy Marshall

#### BBC WORLDWIDE, UK PUBLISHING

Director of UK Publishing Nicholas Brett Head of UK Publishing Chris Kerwin ing Jenny Potter Eva Abramik Contact UK.Publishing@bbc.com www.bbcworldwide.com/uk--anz/ukpublishing.aspx

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## DISCOVERIES

News and views from the world of science

EDITED BY

JASON GOODYER



DAVID SHUKMAN The BBC Science Editor gives you his insights in a new



SOCKING IT TO HEART DISEASE

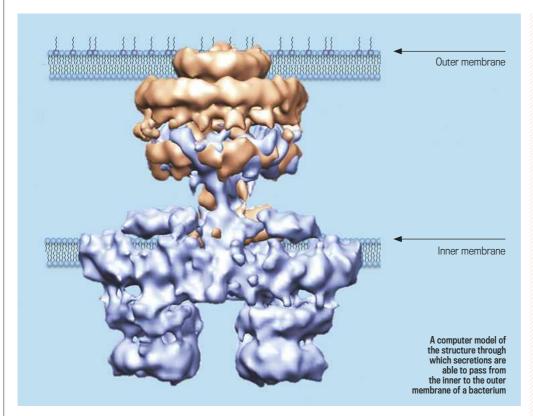
The sensor-laden electronic sock that fits over hearts and keeps them beating



MUSICAL MYSTERY

The condition that means people can't take pleasure from music





team at London's Birkbeck and University College London has uncovered the system through which bacteria share genetic material, most notably the genes that exhibit antibiotic resistance.

The study reveals the action of what is known as the 'type IV secretion' system, which allows bacteria to move substances across their cell walls. The system is a complex structure of proteins that moves secretions through a bacterium's cell envelope – the outermost area of the cell. As well as enabling bacteria to distribute genetic material among themselves, it plays a crucial role in secreting toxins in infections causing ulcers, whooping cough, or severe forms of pneumonia such as Legionnaires' disease.

"The entire protein complex [through which type IV secretion takes place] is huge and its structure is unprecedented," said project leader Gabriel Waksman. "This is ground-breaking work and will provide an entirely new direction to the field. Next, we

need to understand how bacteria use this structure to get an idea of how antibiotics resistance genes are moved around."

The team was able to reconstruct the system as observed in the bacteria *Escherichia coli* using electron microscopy. The mechanism consists of two separate complexes, one in the outer membrane of the cell and the other in the inner membrane. They are connected by a stalk-like structure that crosses the periplasm, the space between the two membranes. The complexes at both the inner and outer membranes form pores in the membrane, via which substances can be secreted.

"Understanding bacteria's secretion system could help design new compounds able to stop the secretion process, thereby stopping the spread of antibiotic resistance genes," says Waksman. "Given that antibiotics resistance has become so widespread and represents a grave threat to human health, the work could have a considerable impact for future research in the field of antimicrobials."

#### ANALYSIS Dr Cath Rees



Associate Professor in Microbiology at the University of Nottingham

WE ARE NOW in

what is known as the post-antibiotic era, which means that we haven't got enough antibiotics that are effective against all of the types of bacterial threats that are coming at us. The antibiotic resistance genes are often found on plasmids that function like the USB stick of the bacterial world. The systems that this research is looking at are the means by which those USB sticks are passed from cell to cell, spreading the resistance genes to new bacteria.

It's not so much that the work is going to revolutionise our understanding of antibiotic resistance, but this is the first moment when we understand the details of the conjugation system [the transfer of DNA], the three dimensional structure and how it is all working. It's a beautiful molecular mechanism. Obviously, years down the line, the idea is that we will be able to control and block the whole thing. At the moment we've just got something to start working with. It's like a blueprint.

Furthermore, these DNA transfer systems are not just important in antibiotic spread, they are also the system we use for genetically engineering plants. When GM plants are created, genes with the desired traits are selected, isolated, and put into a plant. So there may also be future implications for researchers improving those plant genetic engineering systems as well. The more we understand about the system, the better we can exploit it.

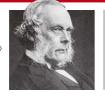


#### TIMELINE

The fight against bacterial infection

#### 1871

The pioneering surgeon Joseph Lister begins researching the phenomenon that urine-contaminated mold could inhibit the growth of bacteria.



#### 1928

Sir Alexander Fleming discovers that the bacterium Staphylococcus aureus can be destroyed by Penicillium notatum, a kind of mold.

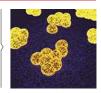


#### 1943

Just four years after pharmaceutical companies began mass-producing penicillin, microbes begin appearing that could resist it.

#### 1961

MRSA (methicillinresistant *Staphylococcus aureus*) is detected in Britain for the first time and goes on to become an increasing problem in hospitals.

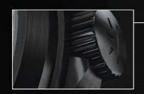




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#### **1 MINUTE EXPERT**

**Dropleton** 



#### What's that? A rare Pokémon, perhaps?

Nope. It's the new quasiparticle discovered by researchers based at Philipps-University Marburg in Germany, silly. It also goes by the slightly more prosaic moniker of 'quantum droplet'.



#### Er... what's a quasiparticle? Rather than consisting

of elementary particles such as quarks and electrons, which can exist anywhere, quasiparticles arise thanks to the complex motions within a material. They behave in a similar way to real particles but can only exist inside solids.



#### So what is the, ahem, dropleton actually made from?

It's a cluster of smaller quasiparticles known as 'electron holes' and electrons themselves. It results from interactions within the 3D lattice of atoms that make up a chunk of semiconducting material.



#### What does it do, then?

Well, dropletons only exist for 25 trillionths of a second, which is actually quite a long time for a quasiparticle. Further study is required to determine their exact properties, but we do know that they behave in ways similar to a liquid.

#### **ANIMAL BEHAVIOUR**

#### Not so bird-brained

PARROTS ARE AMONG the most intelligent creatures in the animal kingdom. Past experiments have shown them to be capable of learning a vocabulary of more than 100 words and understanding concepts such as 'bigger'

and 'smaller'. Now, a study has provided evidence that the animals can understand the benefits of sharing.

In experiments carried out by Dr Franck Péron from the University of Lincoln, an African Grey Parrot named Griffin was asked to choose from a selection of four different coloured cups. Choosing the



got a treat. The human partner then made the same choice as Griffin with the same outcomes and the process was repeated.

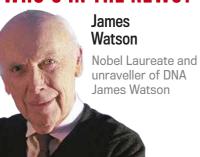
The idea was to investigate whether Griffin could understand that the human was replicating his own behaviour by acting in a reciprocal manner. The parrot quickly learnt that by choosing the green cup both he and his partner would get a treat on each turn.

"He seemed to understand the parameters of the study; that is, that each person was mirroring Griffin's own behaviour and not acting erratically," said Péron. "Although choosing pink would have

presented the same immediate
reward as choosing green, Griffin
did not act in that manner. He
seemed to figure out fairly
quickly that his choice of pink
meant that he would miss a
reward when the human
subsequently made
the choice."



#### WHO'S IN THE NEWS?



#### What did he say?

In an article published in the *Lancet*, Watson proposed a somewhat controversial new theory for the onset of type 2 diabetes. The most commonly held view is that the condition is caused by excess oxidation killing off cells in the pancreas. Watson, however, suspects the disease, along with a whole host of

others, is in fact due to a lack of oxidants.

#### What's his reasoning?

The fact that physical activity helps lower blood sugar in those with type 2 diabetes, and that exercise prompts the body to produce large numbers of oxidants. He also cites a study that showed oxidants released in exercise

lessened insulin resistance in diabetics, but that the benefits vanished if you gave people antioxidants beforehand.

#### What happens next?

Watson has called for a 'more thorough scientific look at the mechanisms through which exercise improves our health,' and is planning a meeting in New York later this year.



#### DAVID SHUKMAN The science that matters

#### After the floods, we must decide how to use science



XTREME WEATHER
brings out the best of
Britain, and the worst.
Along with cheery
camaraderie comes institutional
amnesia. Covering the winter
floods one rain-soaked
afternoon, I was delighted to be
offered a lift in an amphibious
car, its owner piloting what was
essentially a waterproofed Ford
Fiesta along a Surrey street that
had become a river.

Quirky but clever, this contraption proved ideal for filming, and everyone we passed smiled at the eccentric spectacle of a car that was also a boat – apart from a Sky News crew whose gaze was tinged with envy.

But along with the jollity has been the evidence of forgotten promises. One of many examples is that the basic flood defence mechanism is still a bag filled with sand. On a Radio 5 Live phone-in I was asked if sandbags were actually any use - they can be, but only in very localised areas and not for long. In fact, one key lesson from the terrible floods of 2007 was that the rather medieval technique of filling sackcloth by shovel should have no place in an advanced society. Instead, to stop floodwater from flowing through front doors, barriers made of modern materials such as plastic or steel would be far more effective, but these are still not common.

By contrast, no era in human history has ever had better warning of bad weather. In 1953, there were no satellites to spot the storm surge that killed 300 unsuspecting people. Now readings from space and the oceans and the rivers are combined into powerful computer models. In the control room of the Thames Barrier, I was shown the screens foreseeing when trouble might come and how bad it might

be. As forecasts reach one day further into the future with each passing decade, this science has undoubtedly saved lives. The challenge now is deciding how best to use the information, because preparing to face floods is expensive and requires difficult choices about where to protect. Rising sea levels and the prospect of more extremes make this task more serious but, when the sky brightens and the waters recede, it also feels less urgent.

DAVID SHUKMAN is the BBC's Science Editor. @davidshukmanbbc

#### THEY DID WHAT?!

Fake pub set up in London University

#### What did they do?

The psychology department at London South Bank University has set up a fake bar in its main campus building that will be doling out free drinks.

#### That sounds like a recipe for disaster!

Well, there's a catch. Some customers will be given real alcoholic beverages, and some will receive alcohol-free placebos. But even those that get real booze will not be given enough to push their blood-



alcohol levels over the drinkdrive limit. CCTV cameras will relay the actions of the drinkers to students in a nearby room.

#### What's their goal?

The team hopes to gain an insight into how and why people drink alcohol and also to more closely examine the finer details of actions associated with addictive behaviours.

#### PATENTLY OBVIOUS with James Lloyd

Inventions and discoveries that will change the world



#### The need for speed reading

BOOKWORMS REJOICE! A new app means that you could soon be powering through novels in under 90 minutes. Spritz is a speed-reading technology that streams individual words to your mobile device one after the other. Because each word is positioned according to what the developers call its 'optimal recognition point' you won't need to move your eyes to read. The idea is that by eliminating the eye movements you usually make from word to word, your reading speed will be dramatically increased.

The team behind Spritz claims that its technology will increase your reading speed to 1,000 words per minute – nearly five times faster than the average rate of 220wpm. That would mean you could polish off an issue of *Focus* in under an hour, or blitz through *War and Peace* in under 10 hours... if you haven't fallen asleep first, that is. Try out Spritz for yourself at www.spritzinc.com

Patent pending

#### Emotional computers

SOFTWARE THAT CONVERTS text into speech is used in many applications, but existing technologies tend to use voices that sound about as emotional as a plate of turnips. A new system from Toshiba aims to change that by analysing the text and working out how it should be spoken. It'll use sophisticated algorithms to associate different sentences with different tones of voice, meaning that it'll sound happy or sad on the right occasions. Patent application number: GB2505400

#### Your iPhone's got your back

IS YOUR SMARTPHONE your constant companion? If so, it could soon be saving your life. A new patent from Apple describes how an 'attack detection mode' could automatically summon help in an emergency. This may be triggered when the iPhone's accelerometer detects a sudden shock, or when the mic records an unusually loud noise. The phone will then ring the emergency services or emit an alarm to attract passers-by. Patent application number: US 20140066000

#### **ASTROPHYSICS**

#### Supernova seen in a new light

HEY'RE ONE OF the most spectacular events in the cosmos, but little is known about what goes on in the cores of stars during a cataclysmic supernova explosion. These occur when a star runs out of nuclear fuel and is unable to support its own mass; it collapses with a colossal blast.

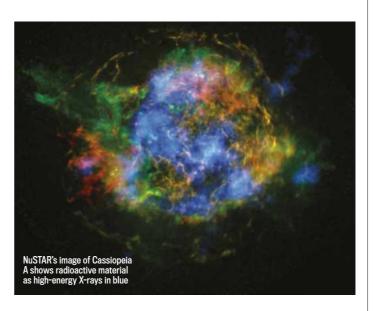
Now scientists have come a step closer to understanding the process as NASA's NuSTAR, a high-energy X-ray observatory, has created the first-ever map of radioactive material from a supernova remnant named Cassiopeia A (Cas A). The image shows the action of shock waves pulsing through the massive star's core during its death throes.

"Stars are spherical balls of gas, and so you might think that when they end their lives and explode, that explosion would look like a uniform ball expanding out with great power," explains Fiona Harrison, the principal investigator of NuSTAR at the California Institute of Technology (Caltech). "Our new results show how the explosion's

heart, or engine, is distorted, possibly because the inner regions literally slosh around before detonating."

Cas A was created 343 years ago when a massive star exploded, ejecting its remains into space and leaving behind a dense remnant. The well-known supernova remnant has been photographed previously by many optical, infrared and X-ray telescopes. But NuSTAR has produced the first map of high-energy X-ray emissions from material created in the actual core of the exploding star: the radioactive isotope titanium-44.

"With the NuSTAR observatory we have a new forensic tool to investigate the explosion," said Caltech's Brian Grefenstette. "Previously, it was hard to interpret what was going on in Cas A because the material that we could see only glows in X-rays when it's heated up. Now that we can see the radioactive material, which glows in X-rays no matter what, we are getting a more complete picture of what was going on at the core of the explosion."



#### COSMOLOGY

#### Cosmic inflation confirmed by ripples in the Universe

FOR A TINY fraction of a second after the Big Bang, the Universe expanded at an exponential rate – a period cosmologists call 'inflation'.

That was the theory, anyway. Now, confirmation has been made by scientists operating an instrument called BICEP2 at the South Pole. The discovery also provided evidence for gravitational

provided evidence
for gravitational
waves – ripples
in the fabric of spacetime predicted by Albert
Einstein but, until now, never
discovered. Physicist and
BBC presenter Jim Al-Khalili
said the discoveries were
by Joh
significant enough to each
win a Nobel Prize.

The telltale signature of
gravitational
waves

Univer
twaves
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travel
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significant enough to each
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Inflation explains why the Universe is as big as it is today. When the Universe came into being at the Big Bang, it measured just 10<sup>-35</sup> metres across. If it had expanded at the rate it's expanding today, it would be no bigger than a full stop.

Evidence for the Big Bang came from the Cosmic Microwave Background radiation, which pervades the Universe and is often called the 'afterglow' of those first moments. The new study looked at a property of this radiation called polarisation.

Polarisation is a property that's exploited to

keep harmful
rays from
your eyes
when it's
used in
sunglasses.
Imprinted
in the
polarisation
of the CMB was

of the CMB was
a telltale signature
of inflation: ripples
in the fabric of the
Universe called 'gravitational

waves'. They produce ripples by squeezing space as they travel along. The discovery was made by a team led by John Kovac of the Harvard-Smithsonian Center for Astrophysics.

The discovery gives hope to larger experiments that have been built to directly detect gravitational waves, but have so far failed to do so. Ultimately, astronomers want to do far more than just find them. They will effectively be a new kind of telescope, joining visible light, infrared, X-ray and gamma-ray instruments in an astronomers' armoury.





New websites, blogs and podcasts

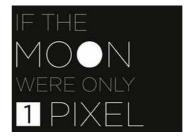


#### **AURORAMAP**

#### www.auroramap.co.uk

To see the Northern Lights, you need perfect conditions: clear skies and plenty of solar activity to trigger the collision of energetic particles with atoms high up in the atmosphere. AuroraMap tracks the K-index – a measure

of disturbances in Earth's magnetic field – and can tell you what the likelihood of aurora is at a particular time and place.



#### PIXEL SPACE

www.joshworth.com/dev/ pixelspace/pixelspace\_ solarsystem.html

We know the Solar System is huge. But it can be hard to grasp just how huge it is from our vantage point on Earth. This 'tediously accurate' scale model of the Solar System

solves that problem by requiring you to scroll (and scroll and scroll) your way through the planets. Spoiler: it's mostly black and empty.



#### NAME MARTIAN CRATERS

#### www.uwingu.com/mars/

You're unlikely to ever go to Mars yourself, but you can leave a mark on the Red Planet by naming one of its craters. There are over half a million unnamed craters on Mars, so there's plenty to choose from. You have to pay

Uwingu to name a crater and, for now, the name only applies on its maps, but it hopes scientists will consider using them in future.



KELLY OAKES is a science journalist who tweets from @kahoakes

#### SUNSPOTTER

#### www.sunspotter.org

The latest project from citizen science specialists behind the Zooniverse project, Sunspotter needs your help in classifying sunspot images according to how complex they are. Eruptions from sunspots are what can eventually cause aurorae here on Earth, so if you fancy yourself as a Northern Lights hunter, this is a great way to get to grips with the underlying science.

## **EDDISCOVERIES THAT**

Greener oil spill clean-up

SOMETIMES WHEN YOU make a big mess, the best way to clean it up is to use a big sponge. The Wisconsin Institute for Discovery's Shaoqin Gong has created a unique aerogel, an incredibly light, highly porous material, made of cellulose fibres derived from wood. The substance repels water and can absorb up to 100 times its own weight in oils and metal ions.

If the material is developed further, Gong says huge sheets of the substance could offer a cheaper, greener method of clearing up environmentally destructive oil spills.



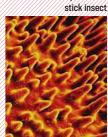
Stick insect shoes

EVER FALLEN OVER while out on your morning run? Well, a study of stick insects' feet could make slippery sneakers a thing of the past.

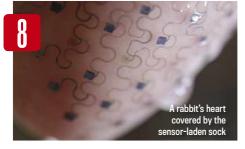
The animals use specially adapted sticky toe pads when climbing up plant stalks or hanging upside down. But when they're on flat ground, they walk on heel pads that feature

a system of tiny hairs that allow the insects to grip but not stick.

Researchers say a similar system could be used to design a pair of training shoes with extra grippy soles.



The hairy heel of a



#### Sock keeps heart beating

IF YOU WANT to keep your heart beating, put a sock on it. Researchers at the University of Illinois have developed a silicone sock decked out with sensors and electrodes that fits over the heart to monitor health and even act as a pacemaker should the need arise.

So far it has been used to keep a rabbit heart beating outside the animal's body. But the team hopes the device will be trialled in humans and is considering developing similar systems to monitor other organs such as the brain.

#### Hurricane wind farm

THEY SEEM LIKE unstoppable forces of nature, but now Stanford University's Marc Jacobson has found a means of combatting hurricanes: huge offshore wind farms.

Using computer simulations, Jacobson found that banks of wind turbines may slow down the outer rotation winds of a hurricane and help them to dissipate faster. In a simulation of Hurricane Katrina, Jacobson has shown that a wind farm of 78,000 turbines could have reduced peak wind speeds from 281km/h (175mph) to 144km/h (90mph).

Hurricane Sandy strikes the US in 2012

#### Growing fat from ears

DOCTORS AT GREAT Ormond Street Hospital are pioneering a technique to grow replacement ears and noses using stem cells taken from abdominal fat. The team plans to take a minute sample of fat, extract stem cells from it and then encourage them to grow on a 'scaffold' in the shape of the proposed body part. It is hoped the technique will help those with facial defects.

Stem cell research could lead to replacement facial parts



## WILL SHAPE THE FUTURE



#### Controlling your hunger

WE ALL FEEL stomach pangs brought on by hunger, but some feel them more than others. But scientists at Harvard University may be able to help. They previously found that a group of nerves in the brain, known as agouti-related peptide-expressing neurones, cause mice to eat voraciously when triggered. They have now linked these neurones to the paraventricular nucleus, a part of the brain that governs the feeling of fullness. The discovery could lead to treatments for eating disorders and obesity.

#### Light-proof plants

ALONG WITH RISING sea levels, extreme weather, and changes in temperature, light and rainfall, climate change could also wreak havoc on the Earth's plant life.

Researchers at London's Queen Mary University have produced a method that enables them to determine how light-sensitive plants are by measuring the fluorescence of



A plant's fluorescence is measured

the sunlightabsorbing chlorophyll stored in their leaves. The team says the findings could help farmers to breed hardier crops.

#### The of 1

#### The language of love

WHAT DO YOU look for in an ideal partner? Well, dialogue expert Molly Ireland has found that meeting someone who talks like you may be the best way to find love. She studied 40 speed dates and found that couples who used 'function words' such as 'he', 'she' and 'but' in the same way were more likely to go on a second date. The findings could improve the effectiveness of online dating services.



#### Silk to repair broken bones

IT MAY BE prized by the fashion industry for its floaty elegance and natural shimmer, but now scientists at Tufts University, USA, have found a new use for silk: fixing

#### broken bones. The team successfully repaired

The team successfully repaired injured lab rats using screws and plates made from protein derived from cilly yours.

from silkworm cocoons. Unlike the metal alloys traditionally used, silk can be absorbed by the body over time, reducing the likelihood of infection and the need for further operations.

One of the silk screws used



#### No thank you for the music

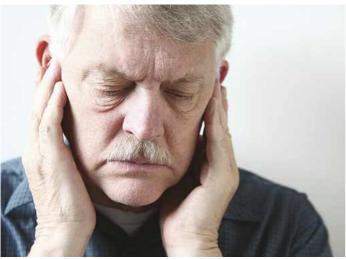
OME PEOPLE ENJOY music so deeply they can be cheered up or moved to tears simply by listening to it. But for others it seems even the most beautiful melody is no more likely to illicit an emotional response than the sound of a pneumatic drill.

These people have 'specific musical anhedonia', an inability to experience pleasure from music. It's a condition that's just been discovered by a team at the University of Barcelona.

The researchers identified the condition by comparing the changes in the electrical conductance of the skin and heart rate, both indicators of emotion. They compared volunteers listening to music to those who played a game that involved winning or losing money.

"The identification of these individuals could help us understand the neural basis of music – that is, to understand how a set of notes is translated into emotions," says lead researcher Josep Marco-Pallarés.

The findings could also lead to a new understanding of the brain's reward system, which may help in the treatment of addiction and other disorders, the researchers say.



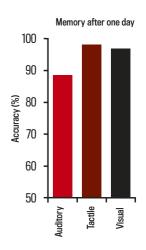
Music may as well be the sound of a drill for those suffering from specific musical anhedonia



If things go in one ear and out of the other, then grab a pen and paper

EVER STRUGGLE TO remember the name of a song you've heard on the radio? Or forget something your partner asked you to pick up on the way home? Don't worry, you're not alone. Scientists at the University of Iowa asked more than 100 students to listen to audio recordings of dogs barking, watch silent videos of a basketball game, and touch objects like coffee mugs that they couldn't see. After just an hour, the accuracy of their memories had begun to decline. However, their memory of visual scenes and tactile objects was better than their memory of sounds. This also held true after one day and one week.

"We tend to think that the parts of our brain wired for memory are integrated. But our findings indicate that the brain may use separate pathways to process information. What's more, our study suggests the brain may process auditory information differently than visual and tactile information," says researcher Amy Poremba.







#### **Genghis Khan's climate**

• If you want to take over the world, wait for the right weather! Tree rings in Mongolia reveal the usually arid central Asian steppes had their wettest weather in more than 1,000 years in the early 1200s. The climate would have led to more grass, and therefore healthy horses and livestock, and enabled Genghis Khan to grow his empire, say scientists from Columbia and West Virginia universities.

#### Ticket to space: £40

• Fancy a trip to space but can't afford the sky-high prices? A group at the University of Surrey may have just the thing. In a crowdfunded project, the team is offering wannabe astronauts a virtual trip to the stars for £40. The 'Virtual Ride To Space' will be created by capturing footage of space via 24 HD cameras attached to a weather balloon. You'll then view the 20km ascent with an Oculus Rift virtual reality headset.

#### **Amazing apes**

• When it comes to spatial reasoning, chimpanzees can outperform humans. A study at the University of Michigan-Dearborn asked four chimps, 12 3- to 6-year-old children, and four adults to navigate complex virtual mazes and measured the distance they covered before they reached the end. One chimp significantly outperformed the adults and children. Others were on a par with the children, but adults beat them.



#### **INSIDE SCIENCE**

### ROBERT MATTHEWS

Don't be fooled by sensational, headline-grabbing statistics

OLITICIANS, WE ALL know, bend statistics to breaking point, but we expect better of scientists. After all, they're focused on getting to the truth, rather than getting publicity. Some research that makes headlines does make me wonder, though. Take the recent claim that heat-related deaths in the UK will soar by over 250 per cent by 2050 because of climate change.

That seemed like typical media hype, so I checked out the actual research paper. It was published in a serious research journal, and its authors were from respected UK public health institutes. And they did indeed conclude that heat related deaths are 'expected to rise by around 257 per cent by the 2050s'.

So, amazingly, the media reports were accurate. Yet after reading it, I discovered it was the research paper itself that was rather misleading. That headline-grabbing figure came from estimates of how climate and population changes will affect temperature-related death-rates over time. As the UK is expected to get hotter, it's pretty obvious the risk of heat-related death will rise. But the study found that the death-rate due to cold weather will fall. Oddly, its authors didn't make much of this which is puzzling, as the fall was so big it actually led to an overall decline in

all temperature-related death-rates.

So where did that huge hike in heat-related deaths come from? Simple: by multiplying the death-rate by the estimated numbers of vulnerable people in the population by

2050. And as these are predicted to soar, the endresult is a hefty rise in raw numbers of just heat-related deaths – one that has nothing to do with global warming, and everything to do with an ageing population.

Cynics might also think it had something to do with getting media coverage. But not everyone was

"As the UK is expected to get hotter, it's pretty obvious that the risk of heat-related death will rise"

taken in. The Science Media Centre, which helps journalists assess new research findings, took a dim view of that misleading '257 per cent' figure. So did one of Britain's most distinguished statisticians, Professor David Spiegelhalter of Cambridge University, who said: "This kind of presentation gives ammunition to those who say that the effects of climate change are being exaggerated." As someone who routinely uses statistical methods, I share his frustration with such apparent proof that "you can prove anything with statistics".



Used with care and sophistication, statistics can extract amazing insights from data. Alan Turing and his colleagues used statistical methods to break the Nazi codes during World War II. In 2012, Nate Silver used similar methods to correctly forecast the outcome of the US presidential vote in all 50 states. Yet statistics also have the power to bamboozle, which is why I believe everyone should be taught how to make sense of stats in school.

Most of us have learned to be wary of research based on anecdote, or small samples of people, or animal studies. We should also be sceptical about research highlighting scarily large relative risks. A ten-fold increase of a piffling risk – like being struck by lightning – is still a piffling risk.

But there are more subtle statistical traps we should look out for – like claims based on absolute numbers rather than rates. Did you know that people over the age of 70 are dying in huge numbers compared to the

1950s? Some might think that's a scandal. The real scandal is that the media and politicians can't – or won't – see such statistical silliness for what it is. ■

ROBERT MATTHEWS is Visiting Reader in Science at Aston University, Birmingham

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#### **EVERYDAY SCIENCE**

### HELEN CZERSKI

Have fun manipulating a world of tiny forces - have sugar with your tea

UGAR LUMPS ARE so much fun - I had no idea. I knew that horses like them, and that you find them in coffee shops in France (where they are wrapped up and stacked like bricks). But my interest in sugar lumps stopped there, until a friend suggested that we indulge in proper afternoon tea in Oxford. We went into the sort of teashop that has very thin china cups, an army of doilies and a constant background melody of refined clinking noises. After my friend's coffee arrived, he picked up a white sugar lump with the posh tongs, but he didn't drop it into his cup. He held it with the lower side barely touching the liquid surface, and the white sugar was suddenly invaded by black coffee. It only took a couple of seconds for the whole lump to go dark brown. And then he let go of it and it fell into the hot coffee below.

This is just beautiful, because it shows why scale matters. We assume that liquids can be poured into containers and will then just stay at the bottom of the container, but that's only the case for anything bigger than a few millimetres across - gravity usually dominates. But if you're smaller than that, other forces matter more, and liquids don't necessarily stay in their containers.

A sugar lump is made of lots of crystals packed together, with tiny spaces in between them. Imagine the jostling molecules in the coffee touching the sugar. Coffee is mostly water, and water molecules are attracted to sugar, so the coffee will slide up the surface of the sugar crystal a little way. But water is also strongly attracted to other

water molecules, and will change its shape to touch as little air as possible. So the water molecules sliding up the sugar surface bring along some other water molecules to reduce the surface area on the non-sugar side.

The channels through

"You can see a world in a grain of sugar, the world of tiny molecules and miniscule forces"

the sugar lump are so narrow that very few extra water molecules have to be pulled up against gravity to minimise the surface area. So the coffee can keep creeping upwards, just because the sugar is attracting water so strongly. This is capillary action – the combination of sugar-water adhesion and surface tension. These adhesive forces are tiny, but when the channels are tiny that's all you need to overcome gravity. The balance of forces is different down at the bottom. Liquids don't just fall down.

When I got home, I bought some sugar lumps and food dye and had bit of a play. Milk rises about three times more slowly through a sugar gravity. The balance of forces is different down at the bottom. Liquids

When I got home, I bought some sugar lumps and food dye and had a



lump than water, and I think that's because it's more viscous. Oil only rises about 6mm and then stops, so that's less strongly attracted to the sugar than the water is.

The lovely thing about this is that we can watch something as large as a sugar lump and see the effect of tiny forces on individual molecules. All the molecules in a liquid are free to move around, and each one is just responding to the forces on it. It's a bit weird to think of water creeping around by itself, but it's happening everywhere. It's why towels are absorbent, and why sports tops wick sweat. Even though we live up here in the macro world, we can engineer materials that have structure on a tiny scale, and that can take advantage of the rules being different when you're small.

I have never had sugar in my tea, but the sugar bowl was empty

DR HELEN CZERSKI is a physicist, oceanographer and BBC science presenter who appears regularly on Dara O Briain's Science Club

by the time we left the tearoom. You can see a world in a grain of sugar, the world of tiny molecules and miniscule forces. And even better than seeing, you can play with them! ■

#### Galloway Forest Park

home to the UK's only Dark Sky Park

## Black Hole discovered in Galloway

Be among the 20% of the UK's population to experience true darkness and the elite 2% that see the Milky Way. Crystal clear skies, protected Dark Skies and the Milky Way stretching from horizon to horizon.

If you want to see stars - then **Galloway Forest Dark Sky Park** is the place to come. Astrophotography shows up our immediate celestial neighbours like no other place in the UK - in proximity to cities & towns. An easy 2hrs from Glasgow and Carlisle, 4.5hrs from the midlands and you reach the astronomers dream location.

With a Bortle classification of 2 and light readings of between 21.9 – 23 it is little wonder that we see Galloway Forest not as a green wilderness but as **black wonder!** 

With astronomy friendly accommodation and **Galloway Forest** Astronomical Society assistance why not come and find your ideal spot in the 300 square miles of Gold Tier darkness.

**Big skies** beautiful settings, quiet roads and fantastic wildlife even day time can be an enjoyable experience. Bring the family along to enjoy miles of walking trails, the world's best mountain biking on the world famous 7stanes and visit the UK's only red deer range.

have ever seen" "This is extraordinary and should not be missed"

"all this and it's free" "I thought it was a cloud and it was
the Milky Way" "I feel as if I could reach up and
touch the stars" "I have never been in such
a dark place, quite an experience"

Visit our website to get all the latest information and links. Come and visit us now and see why we are The UK's only Dark Sky Park

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For more information visit our website or call us on 01671 402420 www.forestry.gov.uk/darkskygalloway

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#### INTO THE FUTURE

### STEPHEN BAXTER

#### The world is increasingly being run by algorithms, but could they ever be intelligent?

IXTY YEARS AFTER Alan Turing's death, our homes and workplaces are increasingly supported by robots, which, like our phones, tablets and other gadgets, can exhibit remarkably intelligent behaviour. What would Turing make of the artificial intelligence all around us today?

Turing is probably best known for his codecracking work at Bletchlev Park during World War II. But in 1952 he was convicted for homosexual activity, then illegal, and died in 1954, aged 41. In December 2013, after a long campaign, he was issued with a posthumous royal pardon. Aside from his war work, Turing is considered to be 'the father of modern computing'.

Turing gave a great deal of thought to the question of how we would recognise artificial intelligence, 'Can machines think?' he asked. He avoided vague questions about the nature of consciousness, and proposed a practical 'Turing test'. If after a long conversation (perhaps via screen and keyboard) you can't tell if the responses you've received were generated by a human or a machine, then for all intents and purposes you have to concede that whatever you're speaking to 'thinks' as well as a human.

Today, some of our smart systems actually do speak to us, communicating in the Turing-test fashion. But much of their behaviour is in fact controlled, not by human-style thinking at all, but by algorithms. These are procedures that encode knowledge or skills in sets of rules. To get the answer, you just follow the rules. The procedure vou learned at school to do long

division sums is an example. Such algorithms go back millennia, to procedures devised by the Greeks for finding prime numbers.

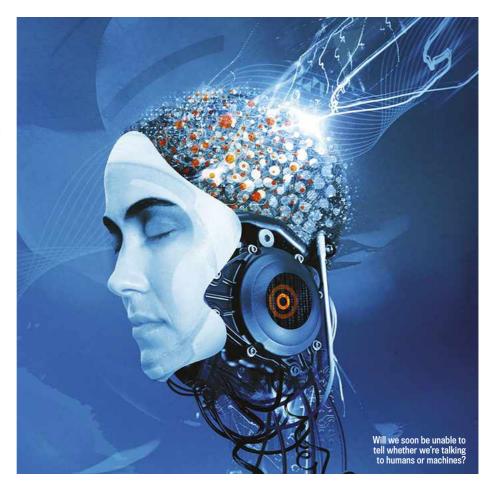
But it has been in the computer age that algorithms have come into their own. A recent book by Christopher

vague questions about consciousness and proposed a practical test"

"Turing avoided

Steiner (Automate This. Portfolio, 2012) describes how it all began with a 1970s program designed to make trades on the New York Stock Exchange;  $\underline{\circ}$  the program, blindly following rules to spot good deals, was soon outperforming many human traders. Steiner says that algorithms now control 60 per cent of all stock trades in the United States. Elsewhere algorithms are used routinely in medical diagnosis, and even in policing. In Memphis, Tennessee, the police use an algorithm called CROSIT CHARLES Utilising Statistical History – to anticipate trouble spots and direct resource Of course the use of algorithms has downsides. In the stock markets feedback effects between superfast algorithms can cause booms and Tennessee, the police use an algorithm called CRUSH - Criminal Reduction Utilising Statistical History - to anticipate trouble spots and direct resources.

Of course the use of algorithms has downsides. In the stock markets,



crashes even before human operators are aware of them. And in the commercial world algorithms can wield awesome power. PageRank is the algorithm Google uses to produce its ranking of results from web searches. Its contents are a commercial secret, naturally enough - but every time Google tweaks the rules the ranking of online presences changes, thus influencing our choices and changing commercial destinies.

The problem for the Turing test is that an algorithm like the long-division procedure isn't a human-like entity you can have a conversation with. It is just a set of rules - even if running those rules on a computer produces apparently intelligent behaviour, such as making smart buys on the stock market. It would be fascinating to know what Turing would have made of the 'intelligence' displayed by today's technology, and how the wide use of algorithms makes the job of spotting true human-like 'thinking' harder.

STEPHEN BAXTER is a science fiction writer whose books include The Science Of Avatar and the Northland series

On the other hand, he might speculate that much of what we grandly regard as our own 'thinking' might be the result of nothing but a bunch of algorithms running on the organic computers in our heads.

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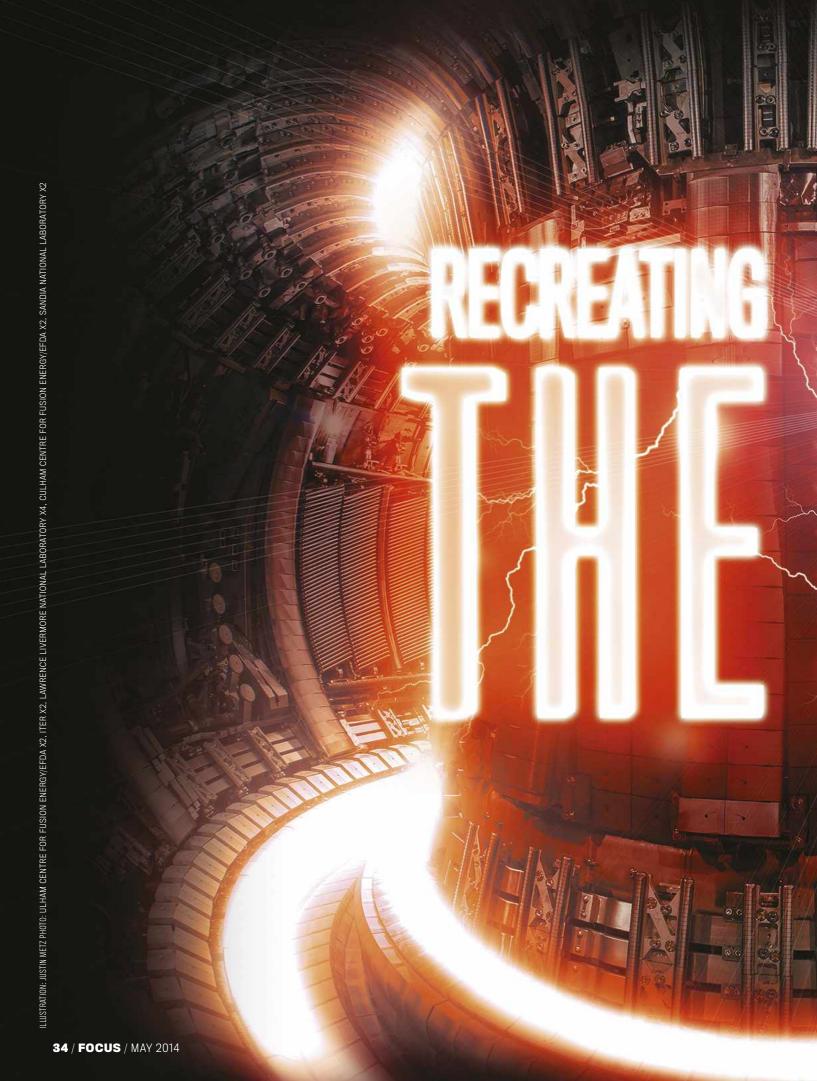




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nuclei of atoms to merge together, forming a heavier substance, a process that releases energy. Fusion was first employed destructively in the hydrogen bomb, but has a great potential for peaceful energy production. Unlike our current nuclear power plants, a fusion generator could never produce a Chernobyl-style disaster, does not produce dangerous radioactive waste and works with readily obtainable fuel.

A typical fusion reactor uses two isotopes of hydrogen: deuterium and tritium. Isotopes are variants of an element with different numbers of particles in the nucleus. Where the standard form of hydrogen has a nucleus that is just a single proton, deuterium adds one neutron and tritium two. It's easy enough to extract deuterium from seawater, while tritium can be made from lithium, the element used in the batteries in much of our

## "A 1GW coal-fired power station uses 10,000 tonnes of coal a day. A similar sized fusion plant would consume 1kg of deuterium/tritium"

portable technology. This is done by bombarding the lithium with neutrons – and once a reactor is set up, it can generate this component of its own fuel, since fusion reactors produce neutrons as waste.

The remarkable thing about a fusion power plant is the tiny amount of fuel it needs. A 1GW coal-fired power station uses around 10,000 tonnes of coal a day. A similar-sized fusion plant would consume around 1kg of deuterium/tritium fuel. This was so



#### **JE I** (JOINT EUROPEAN TORUS)

**DATE STARTED** 1978

**METHOD** D cross-section magnetic confinement plasma tokamak

**SIZE** 6m in diameter

**LOCATION** Culham, Oxfordshire

**COMPLETED** 1982

TECHNOLOGY – JET is the world's largest functioning tokamak, using a doughnut–shaped ring of plasma, held in place by a magnetic field to produce nuclear fusion at high temperatures. An essential tool in preparing for ITER, JET uses deuterium alone, but is the only tokamak that can use the deuterium/tritium needed for generation.

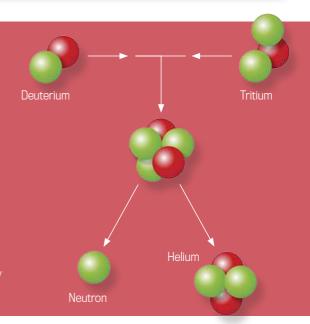
ODDS OF WINNING RACE\* - Evens

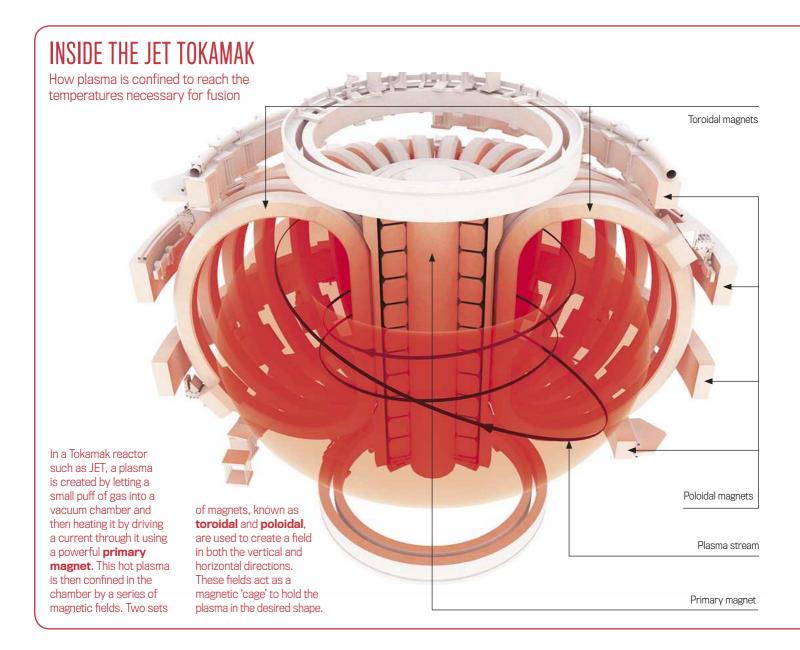
\*All odds are our best guess as to the chances of the design leading to a successful fusion reactor.

## FISSION VS FUSION Neutron U-236 Barium Krypton Neutrons

#### **♦ FISSION**

Nuclear power stations use the fission reaction. When a Uranium-235 (U-235) nucleus absorbs a neutron it is transformed into an unstable U-236 nucleus. This then splits into two pieces, for example Barium and Krypton, and a number of free neutrons. Each of these neutrons can then trigger a split in a further Uranium atom causing a chain reaction. Heat is caused by the kinetic energy of the decay products.





#### **♦FUSION**

A fusion reactor typically brings together deuterium nuclei (hydrogen with one extra neutron) and tritium nuclei (hydrogen with two extra neutrons) under high temperatures and pressures. This forms helium and a free neutron. Kinetic energy produced by a loss of mass, as illustrated in Einstein's famous equation E=mc², generates heat.

obviously a good thing that work on fusion power began shortly after World War II. Yet we still have a number of decades to go before any of the contenders will be able to provide practical power generation. Why has it taken so long? Simply because it's an incredibly difficult process to keep going.

Even this has its good side. Unlike a fission reactor, a fusion power station is not going to go critical or melt down or explode. Unless everything is just right, the reaction simply stops. But this reluctance to keep working makes the whole process a huge challenge. The problem is that the positively charged nuclei of atoms really don't want to fuse together. Bring together two such particles and they repel each other. The closer they get, the stronger the repulsion. But to enable them to fuse, they have to be incredibly close before the nuclear force that binds them together, which operates over tiny distances, cuts in. Anything over 2.5 femtometres (2.5/1,000,000,000,000,000 metres)

and the force hardly exists. In a star, like the Sun, three factors combine to make this possible.

One is high temperature. The core of the Sun is around 15 million °C. This means that the nuclei that are going to fuse have a lot of kinetic energy and take a lot of stopping as they fly towards each other. A second factor is pressure. The Sun is a massive object and the sheer gravitational pressure on the particles inside it is immense. And finally there is the strange behaviour of quantum particles, like these nuclei. They undergo a process called quantum tunnelling that means they can jump through a barrier, like the repulsive force, and appear close to another particle. A fusion reactor has to simulate these intense conditions.

One approach, adopted by some of the contenders in the fusion race, is to go all out for heat. Without intense pressure accompanying it, this means that astonishing temperatures in excess of 100 million °C are required. Inevitably it brings

10

is the energy factor expected from ITER, ie 10 times as much energy out as you put in. sizeable challenges in getting the fuel up to that temperature, and making sure that it doesn't come into contact with anything else. That might seem an impossible restriction in itself. How can you prevent the fuel from touching the reactor? Luckily, the difficulty that makes fusion nearimpossible in the first place – the electrical charge on the particles to be fused – comes to the rescue.

Ever since Victorian times we've known that electrically charged particles can be steered by magnets. It's how the old cathode ray tube TVs worked. So these ultra-high temperature machines keep their fuel away from the machine itself by using a kind of magnetic bottle, an intensely powerful magnetic field that pushes the stream of charged particles away from the wall of the generator.

Historically there were a whole range of configurations for this 'magnetic confinement', but in recent years one approach has dominated – the tokamak. This Russian acronym roughly means

#### "The next big step, ITER will still not be a usable power plant, but it should crack the break-even barrier"

'toroidal chamber with magnetic coils' (there is some argument over exactly what the original phrase was). The 'toroidal' part tells us that the fuel is contained in a chamber the shape of a ring doughnut, though most modern tokamaks have a roughly D-shaped cross-section.

Surprisingly, getting up to those intense temperatures has not proved the biggest problem in



taking tokamaks towards a workable fusion generator. The heat is generally produced by a combination of friction, caused by the resistance of the charged particles to a high electrical current, an energy boost from a blast of radio waves, and supercharging by firing a stream of high-speed neutral particles into the chamber. These collide with the fuel and give it extra kinetic energy and hence temperature. Rather than the high temperatures, the biggest factor slowing the development of tokamak reactors has been the intransigence of plasma.

Plasma is the fourth state of matter after solid, liquid and gas. Just as a gas is what you get when you heat a liquid, a plasma is the result of heating a gas. Unlike a gas, which is made up of atoms or molecules, a plasma consists of charged particles, known as ions, produced when atoms gain or lose electrons. The positively charged nuclei that are the fuel of the fusion reactor form a plasma.

6'30"

is the world record duration of plasma in a tokamak, in ITER's predecessor at Cadarache, France. And plasmas behave terribly. Inside the magnetic confinement they writhe and pulsate as if they were alive. This can lead to a collapse of the electrical current through the plasma – a 'disruption' or contact with the metal vessel, which both stops the process and causes considerable damage.

It's difficulties like these that have set back progress. The early experimenters on fusion machines expected a similar development timescale to that of nuclear fission, which went from early experiments to the first practical power generation in around 10 years. In reality, more than 50 years in, we are still decades from a tokamak reactor joining a power grid. The most advanced of the existing reactors, JET (Joint European Torus), based at Culham in Oxfordshire, has made the biggest leap forward so far. It's given us an understanding of how to get consistent performance out of a fusion device.

The next big step, ITER, will still not be a usable power plant, but it should crack the break-even barrier. Clearly, to be useful as a generator, a fusion reactor has to provide more energy than is put in to keep the plasma contained, and at high temperatures. JET has never achieved this, but ITER should by a wide margin, providing the experimental foundations for the first true fusion generator. ITER is a vast project that suffers from the inevitable bureaucratic difficulties of managing input from seven different countries with their own agendas. Timescales have slipped and the cost has tripled to around €16 billion, while a recent external assessment has slated its management. But despite these problems, ITER remains an essential step on the path to fusion power.

#### **PRACTICAL POWER**

A second device at Culham, the Mega Amp Spherical Tokamak (MAST) is being used to find out how to make a practical generator. "We hope that MAST will show us how to drive down the cost and size of a practical fusion reactor," said Professor Steve Cowley, director of Culham. "Going with the ITER model for electricity generation could result in machines that are too big and expensive. We can't expect the first commercial reactors to be competitive on price, but they need to be in the ballpark. And it's important they aren't too big, or a failure would have too big an impact, and the grid couldn't cope with the input. Around 1GW is best."

The spherical tokamak is helping scientists learn how to produce a smaller, more cost-effective device. A true spherical machine would not be suitable for a production reactor as it wouldn't have enough space to stop the heat-generating neutrons and harness their energy. But a hybrid between the MAST-style spherical design and the traditional D cross-section tokamak may well be the pattern for commercial machines in the future. In the meantime, though, another contender has been working on beating the tokamak to the prize – a fusion device that is straight out of a Bond villain's armoury.

At the Lawrence Livermore National Laboratory in California two vast, 10-storey halls contain the mechanism of the National Ignition Facility



ITER
(INTERNATIONAL THERMONUCLEAR
EXPERIMENTAL REACTOR)

**DATE STARTED** 2007

**METHOD** D cross-section magnetic confinement plasma tokamak

**SIZE** 12m diameter

**LOCATION** Cadarache, France

**ESTIMATED COMPLETION DATE 2020** 

TECHNOLOGY - ITER is a scaled up version of JET that can hold 10 times the volume of plasma. ITER is still an experimental machine, but should easily be able to produce more energy than is put in. The facility will be used to test the technologies required to make a commercial fusion power station.

ODDS OF WINNING RACE 3 to 1

# "A powerful shockwave compresses the fuel so that fusion begins. In effect it's a tiny hydrogen bomb"

(NIF), designed to enable inertial confinement – compressing the fuel enough to initiate fusion. The idea is audacious in its simplicity: blast a small pellet of deuterium/tritium fuel with intense laser light from all directions. The outside of the pellet instantly vaporises with such intensity that a powerful shockwave travels inwards, compressing the fuel to the extent that fusion begins. In effect it's a tiny hydrogen bomb.

Here's how it works. A small triggering laser's infrared output is split 48 ways before each subbeam passes through an amplifying laser, boosting the beam's power by a factor of 10 billion. Each of those beams is then split again, producing a final 192 beams. These pass through the vast main amplifiers, adding another factor of a million to bring the overall power up to a sizzling 6 megajoules. The flash is so powerful that for a few trillionths of a second it is as if the output of 5,000,000,000,000 traditional light bulbs were concentrated into a tiny, but immensely powerful, flare of coherent light.

These 192 beams are converted to ultraviolet, better suited to its final task. In a reaction chamber the beams converge on the tiny pellet, producing that sudden, shocking compression. News reports over the last few months have picked up on the milestone at NIF that researchers have managed to get more energy out of the fuel than they put into it. As is the case at ITER, this is obviously essential if fusion is ever to be used for power generation. But the achievement is not as impressive as it sounds.

Although more energy came out of the fusion reaction than was applied to the fuel, far more was required to run the NIF machine. The process of amplifying the lasers is very inefficient, so most of the energy that is pumped into the system is lost long before the beam reaches the fuel in its 'hohlraum'. This German word meaning 'cavity' was

first applied to the casing of hydrogen bombs but has come to be used for the fingernail-sized gold plated container that

There is a long haul indeed to get from the current laser confinement experiments to a working reactor. Firstly, each shot of fuel is extremely expensive, costing around £600,000; a production

holds the fuel ready for

the beam to zap it.

16
MEGAWATTS

is the world record fusion power output, recorded at JET in 1997.





#### **NIF** (NATIONAL IGNITION FACILITY)

**DATE STARTED** 1997

**METHOD** 192-beam laser inertial confinement **SIZE** 2x approx. 3,200m<sup>2</sup> laser bays, 10m target chamber

LOCATION Livermore, California
COMPLETED 2009

TECHNOLOGY – At NIF, 192 laser beams converge from all directions on a tiny deuterium/ tritium target. The sudden surge in energy as the surface soars in temperature blasts the target inwards, compressing and heating until fusion takes place. It was built to study both nuclear fusion for power generation and for weapons.

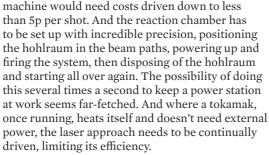
**ODDS OF WINNING RACE** 5 to 1

# 500 TERAWATTS

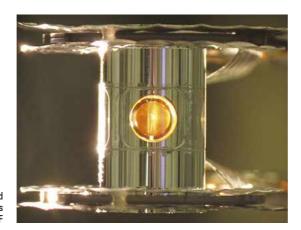
is the peak power of the NIF laser.

A 2mm-diameter target of fuel that will be hammered at NIF by powerful lasers triggering a fusion reaction

> A metallic case called a hohlraum holds a fuel target at NIF



Culham's Steve Cowley is doubtful that NIF will ever result in a fusion generator, pointing out that



while current plans are to increase the site's power by a factor of three or four, it would need something like a 200-fold improvement to be commercial. And that's not the only problem, as the explosion could become too powerful to confine. "Scaling it up, the explosion gets too big. A 2GW explosion is the equivalent of half a kiloton of TNT," he says.

#### **FEELING THE PINCH**

It is likely that, were it not for the military application of NIF's ability to experiment with small scale fusion bombs at a time when nuclear testing is banned, this vast experiment would not even be in the running in the power generating race. Lasers don't provide the only possibility for using confinement, though. The Z-machine at the Sandia National Laboratory, operated for the US Government by Lockheed Martin at Albuquerque in New Mexico, takes a different approach to achieving that dramatic compression, employing a 'Z-pinch'.

The pinch effect was first discovered in a dramatic accident in the early years of the 20th Century. A lightning strike hit the chimney of Hartley Vale Kerosene Refinery in New South Wales, Australia. Engineers there were baffled by the impact the bolt of lightning had on their lightning conductor, a copper tube, which they sent to the physics department of the University of Sydney. A section of the pipe seemed to be have been





crushed by a great force, collapsing it as if it were a straw.

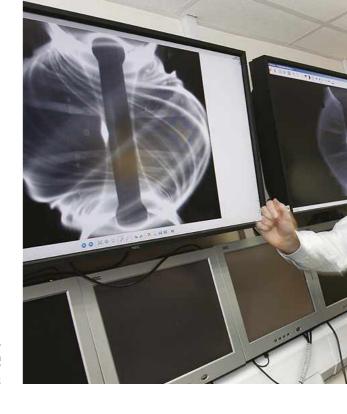
The electrical current flowing through the lightning conductor from the strike had produced the same effect as an electric motor. The electricity, moving through a magnetic field (in this case generated by the electricity itself) produced an inwards force on the tube. The pulse was so intense that it collapsed the tube. Named the 'pinch effect', this was considered little more than an amusing oddity until work began on fusion generators. It's a variant on the pinch effect that keeps the plasma away from the walls of a tokamak. And in the Sandia Z-machine, the pinch from a vast electrical discharge is used to create fusion by inertial confinement.

In this monstrous electrical device, 20 megaamps of current are blasted through hundreds of extremely thin tungsten wires. It's like plugging an old-fashioned light bulb directly into the National Grid. Discharged in around 100 nanoseconds, the

## 3,700 MILLION

degrees Celsius is the highest temperature produced by the Sandia Z-Machine.

Researchers study the pattern of plasma generated in the MAST experiment's tokamak



FUSION DESIGN #4

80 trillor watts courses through the Z-mashine

SANDIA Z-MACHINE (7-PINCH)

DATE STARTED 1997
METHOD Z-pinch inertial confinement
SIZE 30m-diameter chamber
LOCATION Albuquerque, New Mexico
COMPLETED 1997

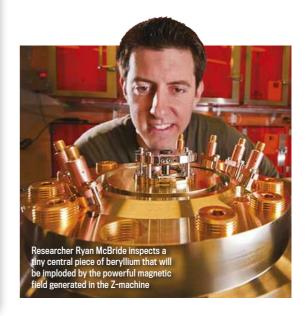
**TECHNOLOGY** The only one of the

devices not built from scratch, the 1980 Particle Beam Fusion Accelerator was upgraded to the Z-machine in 1997 (itself later upgraded). It uses the 'pinch' effect, where a powerful electrical current produces an inward force on charged particles to produce intense heating and compression.

ODDS OF WINNING RACE 4 to 1

Z-pinch produces 80 trillion watts (five times the output of every power station in the world combined). The wires vaporise, forming a plasma that is driven inwards by the pinch effect. This also generates high intensity X-rays which blast a hohlraum, producing a variant on the NIF approach known as magnetised liner inertial fusion. The technology is impressive and a lot more compact than the NIF, but once again the daunting practical difficulty of replacing both the wires and the hohlraum over and over has to be faced if this approach were ever used for power generation.

We have a long road to travel before fusion can supply the National Grid. Each of the technologies has difficulties with the stability of the plasma. This has been an issue in tokamaks for many years, with many modifications to the design made to counter it, but has not really been addressed until recently with inertial confinement, where the main thrust has been to get as much energy out of a single shot as possible. Late last year, though, Sandia announced





that a change to the Z-machine, adding secondary electrical coils in a formation known as a Helmholtz pair, restrained the plasma in a way that had never been seen before. This kind of incremental development is essential, but painfully slow.

#### A WORK IN PROGRESS

Looking at the plan for tokamaks to reach working generators shows how far we still have to go. Though ITER will be twice the size of JET in every dimension, it still won't be a working generator. The aim is to get considerably more power out than is put in, but ITER is still a study machine. It is the next device after ITER that is hoped will be the first true generator, and even that will still be an experiment, requiring one further stage to get to the production machines that could pump out energy. For inertial fusion devices, the path is less clear. There really isn't yet a route from the NIF or the Z-machine to reliable generating capability.

There can be no doubt that achieving a working fusion-based power station has been far more difficult than was first envisaged. The basic physics is well understood. We have clear examples in the stars of fusion reactors acting as huge producers of energy that stand the test of time. And there has never been more need for a large scale, clean, green source of energy that doesn't consume scarce resources and doesn't leave a legacy of radioactive waste. Nuclear fusion has everything to play for.

It is unlikely that we will ever reach the vision of "energy too cheap to meter". This quote from Lewis L Strauss, an early chairman of the Atomic Energy Commission hangs like a spectre over those trying to defend the cost of nuclear power plants. It has often been assumed that Strauss was talking about nuclear fission, but the chances are that he had fusion in mind. Given the difficulties involved, it seems unlikely even fusion will ever be so cheap.

"We haven't proved that it is economically viable," says Prof Cowley. "We are still focussed on whether or not it is feasible. I know that we can do fusion, but



2050

is when the first fusion power station will enter service. no one is certain if we can do it at the required scale within reasonable costs." But with all its advantages over current power sources, it would be a waste if all the work on nuclear fusion did not result in a transformation of our energy production in the future. It might take another 40 years – but there are people alive today who will benefit from the change in energy generation that fusion will bring.



Listen to 'Nuclear Fusion Heating Up', an episode of *Science In Action*, which explores the NIF fusion experiment. http://bbc.in/lje27IR

BRIAN CLEGG is a science writer and the author of *Dice*World: Science And Life In A Random Universe (Icon Books)



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Parm Mann, HEXUS.net

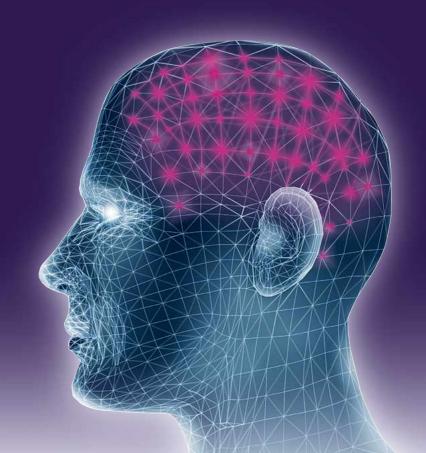
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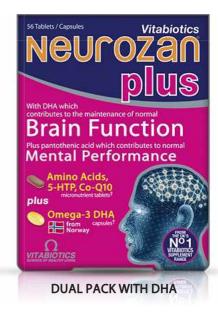
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# BLAGS HOLES EXIST

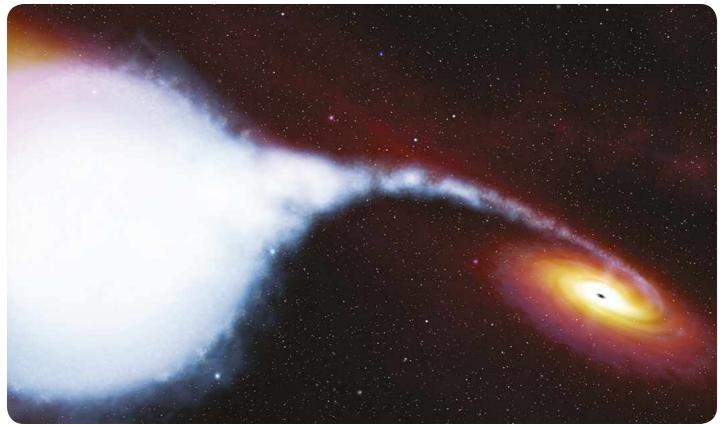
They are the most enigmatic objects in the Universe; we can't see them and we don't know what happens in their depths. Now Stephen Hawking thinks that black holes may not be the inescapable beasts we believe them to be, as **Marcus Chown** reveals

NCE UPON A time it was thought nothing could escape a black hole, including light. This is, of course, the origin of their blackness. Then along came Stephen Hawking, who stunned the world of physics by showing that the space around a black hole emits photons of light and other subatomic particles. Now, more than four decades after the bombshell of 'Hawking radiation', the world-renowned Cambridge physicist may have done it again. In a new paper, Hawking claims that stuff can actually leak out of a black hole. If he is right, black holes are not what we thought they were. In fact, in the strictest sense, they may not even exist.

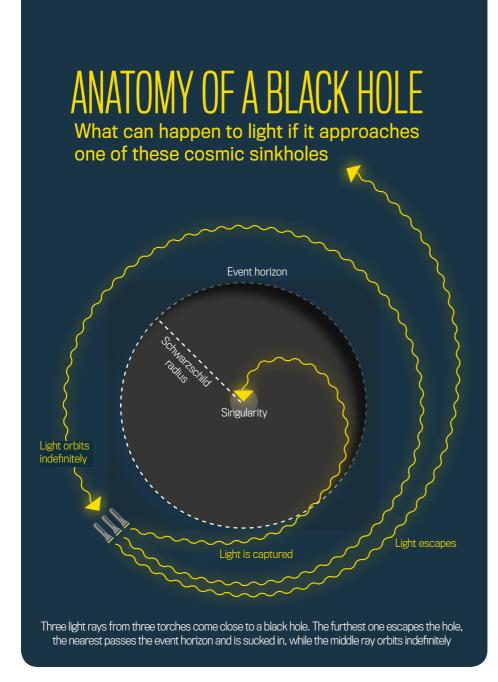
A common way a black hole forms is when a massive star runs out of fuel to burn in its core. With insufficient heat to oppose the gravity trying to crush the star, the core shrinks catastrophically down to a point-like 'singularity'. The singularity is cloaked by an 'event horizon', an imaginary spherical surface that marks the point of no return for in-falling material. The existence of such a horizon was first



Stephen Hawking has once again shocked the world of physics by casting into doubt how 'black' black holes really are



An artist's impression of Cygnus X-1, a black hole that leaches material off a neighbouring supergiant star. The material heats up as it nears the black hole, giving off powerful x-rays



deduced in 1916 by Karl Schwarzschild, using Einstein's brand new theory of gravity. The first real black hole, Cygnus X-1, was discovered in 1971 by the Uhuru x-ray satellite. Now about a dozen black holes are known in the Milky Way, though there are believed to be millions more.

In addition to stellar-mass black holes, however, nature boasts another, even more dramatic type. The first hint of their existence came with the discovery of 'quasars' by Dutch-American astronomer Maarten Schmidt in 1963. Quasars typically pump out the energy of a hundred normal galaxies from a volume smaller than our Solar System. The only plausible source of their prodigious light output is matter heated to incandescence as it is sucked down into a black hole. But this is no normal black hole – it would be a black hole up to

#### "If Hawking is right, black holes are not what we thought they were; they may not even exist"

30 billion times the mass of the Sun.
Initially, such 'supermassive' black holes were thought to power only the unruly 1 per cent of galaxies known as 'active galaxies'. But, to everyone's surprise, it turned out there was a slumbering supermassive black hole in the heart of



The centre of our Galaxy glows with x-rays produced by a supermassive black hole known as Sagittarius A\*

pretty much every galaxy. The Milky Way, for instance, contains a moderate version, Sagittarius A\*, which is a *mere* 4.3 million times the mass of the Sun.

#### **SOMETHING FROM NOTHING**

In 1974, Hawking discovered something amazing about the horizon surrounding a black hole. Black holes, in addition to powering some of the most energetic objects in the Universe, also provide theorists with a unique window on physics in the most extreme conditions imaginable. Quantum theory, our very best description of the microscopic world of atoms and their constituents, permits a submicroscopic particle and its 'antiparticle' to pop into existence, literally out of nothing – just as long as the pair 'annihilate' each other and vanish within a split-second. Hawking found that, just outside the horizon, it is possible for one particle of a pair to fall into the hole while the other escapes. With nothing to annihilate with, the left-behind particle is endowed with a permanent existence. Such particles, streaming away from the horizon in all directions, comprise the Hawking radiation.

The energy to create such particles must come from somewhere. In fact, it comes from the gravitational energy of the black hole, causing the hole to shrink and eventually vanish altogether. This poses a big problem because a cornerstone of physics is that information cannot be created or destroyed. If the black hole eventually vanishes, where does the information that described the star

#### TYPES OF BLACK HOLE

#### Stellar nass black holes

These form from the runaway gravitational collapse of a massive star that has reached the end of its life and no longer has any fuel to burn to stave off catastrophe. They weigh in at anything between three and several tens of times the mass of the Sun.

#### Supermassive hlack holes

These can weigh up to 30 billion times the mass of the Sun and exist in the hearts of galaxies. No one knows how they form. One possibility is that a dense cluster of stars collapses under its gravity to form a black hole, which then grows by sucking in matter.

#### Intermediate nass black holes

This is a hypothetical class of black holes with masses in the range of hundreds to thousands of times the mass of the Sun. Possible evidence for them comes from ultra-luminous x-ray sources. They might form by the merger of stellarmass black holes.

#### Primordial black holes

The violent conditions in the Big Bang may have created 'primordial' black holes. Conditions at the so-called quark-hadron transition, when the Universe was a millionth of a second old, could have spawned Jupiter-mass black holes the size of a fridge.

that spawned the black hole go? In recent years, physicists have concluded that Hawking radiation is 'modulated' – just as a carrier wave of a radio station is modulated by human voice – and gradually returns the information about the star to the Universe.

#### **UNTANGLING BLACK HOLES**

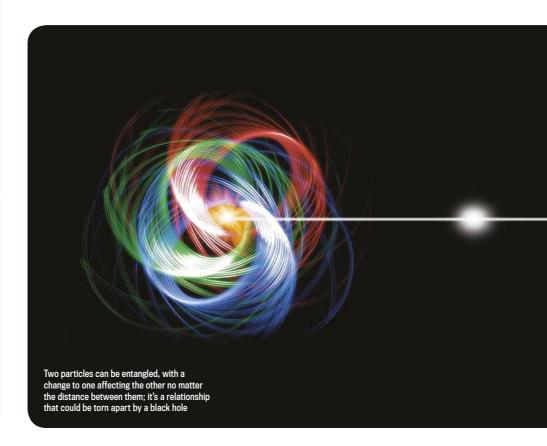
But black holes have not stopped surprising physicists. Not by a long chalk. In 2012, Joe Polchinski of the University of California at Santa Barbara and his colleagues were thinking about Hawking radiation and 'entanglement'. This is the bizarre ability of quantum particles that are born together to forever 'know about each other', almost as if they are the same particle. A Hawking particle is entangled with its partner that falls into the hole. But Polchinski proved that, if a Hawking particle streaming away from the hole is to carry information back to the Universe, it must also be entangled with other Hawking particles emitted at earlier times by the hole.

The problem is that quantum theory permits a particle to be entangled with only one other particle. Something

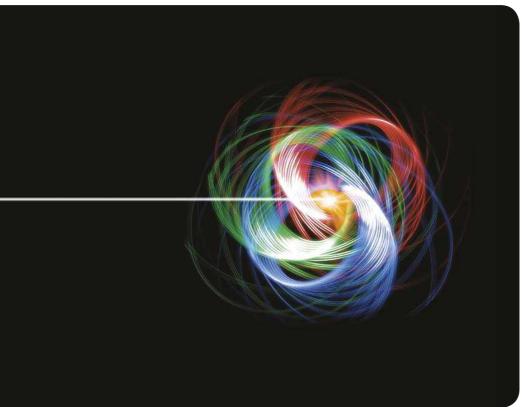
#### "It sounds like Stephen Hawking is replacing a [black hole's] firewall with a chaos-wall"

Theoretical physicist Joe Polchinski of the University of California, Santa Barbara

must therefore intervene to destroy the entanglement between the particle that escapes the hole and its partner that falls into the hole. Since entanglement is an extremely strong bond, this requires the input of an enormous amount of energy to smash it apart. Polchinski and his colleagues concluded that the in-falling particle, as it crosses the horizon, must be met by a searing hot wall of high-energy particles. This 'firewall' creates a paradox since a cornerstone of Einstein's theory of gravity, which describes black holes, is that the world to an observer free-falling into a black hole appears exactly the same as the world to an observer in empty







space. Polchinski's firewall implies that falling through the horizon is dramatically different to being in empty space.

It is to sidestep this 'firewall paradox' that Hawking has stepped into the fray. The collapse of an object such as a star to form a black hole is violently chaotic. Rather than a horizon, all that forms, claims Hawking, is a boundary of extreme spacetime turbulence. Information can leak out through such an 'apparent horizon', so there is no need to worry about pesky entanglements and destroying them with a firewall. Since the firewall is nothing more than a fiction, there is no contradiction with Einstein's theory of gravity.

Hawking's conclusion is dramatic. "The absence of event horizons mean that there are no black holes – in the sense of regimes from which light can't escape to infinity," he explains. "There are, however, apparent horizons which persist for a period of time."

Of course, Polchinski's firewall had to gain its energy from somewhere and that could only be the violently convulsing space-time within the horizon. So isn't the idea very similar to Hawking's? "If I just read the words in his paper, it sounds like he is replacing a firewall with a chaos-wall, yes," says Polchinski. "But I doubt that this is what he means." The trouble, he says, is "Hawking's paper is short and does not have a lot of detail, so it is not clear what his precise picture is, or what the justification is."

So is the horizon around a black hole the point of no-return everyone thought it was? Or is it merely an apparent horizon, as Hawking maintains, leaking stuff from inside the hole? The answer may come from radio astronomers who are trying to image Sagittarius A\*, the black hole at the heart of our Galaxy. They need merely to zoom in by another factor of three and they will see the horizon itself. Currently, nature is hiding its ultimate secret. But it may not be able to do so for much longer.

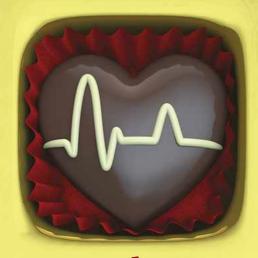


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Listen to 'Black holes', an episode of *In Our Time* with Melvyn Bragg.

http://bbc.in/JEWRMy

MARCUS CHOWN is the author of What A Wonderful World: One Man's Attempt to Explain The Big Stuff, published by Faber and Faber How guilty should you feel about devouring sweet treats this Easter? **Lilian Anekwe** reveals 10 scientific reasons why chocolate isn't all bad



## **1** Lowers blood pressure

Substances called flavanols in cocoa work like blood pressure-lowering drugs called ACE inhibitors. Flavanols stimulate the body to produce nitrous oxide in the blood, which helps open up blood vessels. Australian researchers found regularly consuming cocoa lowered people's systolic blood pressure (blood exiting the heart) and diastolic blood pressure (blood entering the heart). However, 1 per cent of people had stomach aches from over-indulging!



2

Prevents liver damage

The beneficial effects of chocolate

on blood pressure come from the high

flavanol content, and the nitrous oxide

which dilates blood vessels. High blood pressure in the veins of the liver is thought

to be linked with liver damage and chronic

liver disease. Early research has shown

that dark chocolate improves blood flow

in the liver, and there are studies at the

moment looking at whether dark chocolate

can prevent liver damage. Don't have that

second glass of wine just yet though...

#### Boosts 'good cholesterol'

Cocoa contains chemicals called polyphenols, and eating chocolate with high polyphenol levels – like that found in dark chocolate – could improve 'good' cholesterol levels, according to registered nutritionist Gaynor Bussell. "Cocoa consists mainly of stearic acid and oleic acid. Stearic acid is a saturated fat, but unlike most saturated fatty acids, it does not raise blood cholesterol levels. Oleic acid, a monounsaturated fat, does not raise cholesterol and may even reduce it."



4

#### Keeps your heart healthy

All the effects of chocolate on the circulatory system – lowering blood pressure, opening up the blood vessels and reducing inflammation – can help keep our hearts healthy and ward off heart disease and strokes, research published in the *BMJ* shows. A review of studies of more than 114,000 people found that those who ate the most chocolate were 37 per cent less likely to have coronary heart disease and 29 per cent less likely to have a stroke than people who ate the least chocolate.



## **5** Makes you feel good

A study in the Journal Of
Psychopharmacology found people
who had a 42g dark chocolate drink a
day felt more content than people who
did not. Junee Sangani, a dietitian and
spokesperson for the British Dietetic
Association, explains why: "The

improvement in mood that people can get from eating chocolate comes from the release of serotonin and endorphins – the feel-good chemicals – in the brain."



#### Boosts brain power

According to Oxford University researchers, chocolate can make us smarter. In a study reported in the *Journal Of Nutrition*, researchers examined the relationship between brain performance and chocolate consumption of 2,031 Norwegian people aged between 70 and 74. They took a battery of brain-power tests and those who had chocolate (as well as wine and tea) had significantly better cognitive performance than those who did not.



#### Keeps you slim

People who eat chocolate regularly tend to be thinner, according to a study of more than 1,000 people who were all asked: 'How many times a week do you consume chocolate?' The researchers, who published their results in the *Archives of Internal Medicine*, found people who ate chocolate a few times a week were, on average, slimmer than those who only ate it occasionally – even after the other foods in their diet were taken into account.



8

#### Makes you a genius (maybe...)

A study published in the New England Journal Of Medicine found a link between the amount of chocolate eaten per person and the number of Nobel prize winners in a country's population. Switzerland had the highest levels of chocolate consumption and the most Nobel laureates. The researchers calculated that everyone in the UK would have to munch through about 2kg of chocolate per year to increase the number of Nobel laureates. So get eating – your country needs you!



9

#### Renovates blood vessels

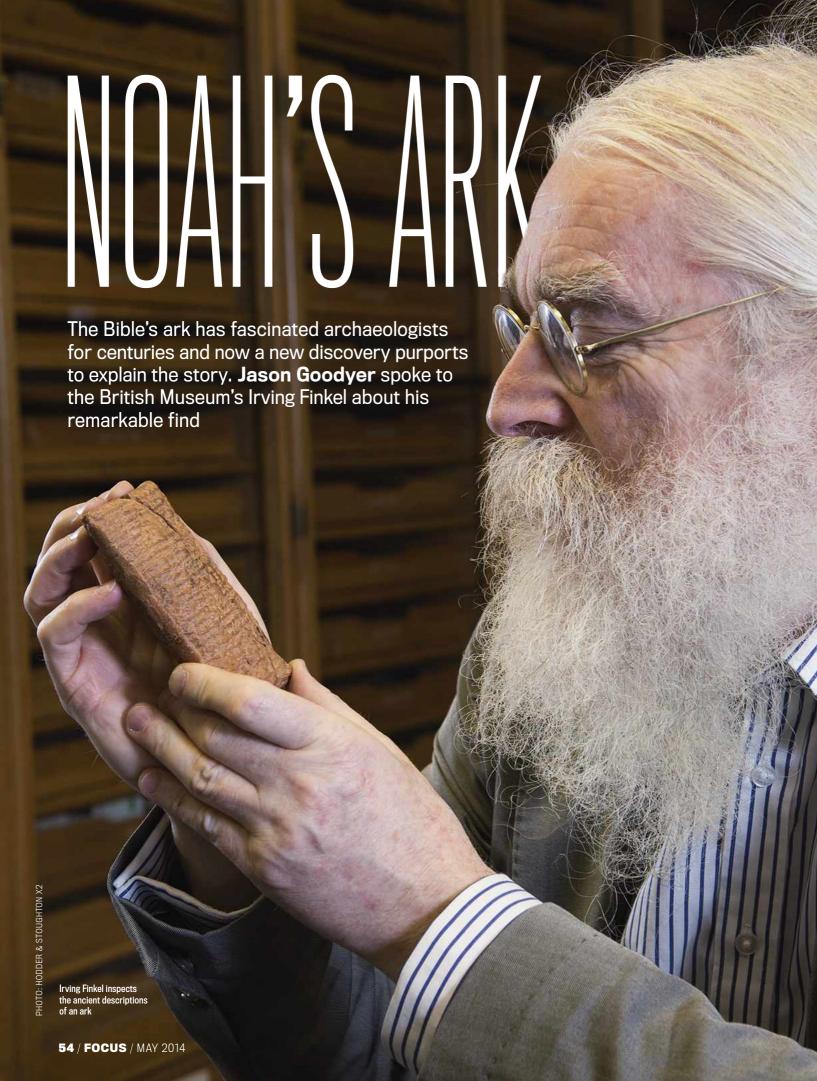
Polishing off a small amount of chocolate a day can help polish up your arteries. A study published by the Federation of American Societies for Experimental Biology found that men who had eaten 70g of dark chocolate a day had healthier blood vessels as a result. The dark chocolate appeared to help make arteries more flexible and reduce the stickiness of white blood cells, two factors that would help reduce the risk of getting them clogged up.



10

#### Protects your skin

Conventional wisdom would have you believe that chocolate can be bad for your complexion, but researchers have found that some compounds in cocoa can actually help protect your skin from the Sun. A study published in the journal *Nutrition* discovered that people who ate 20g of dark chocolate per day over 12 weeks could spend double the amount of time in front of a UV lamp before their skin reddened compared with those who had eaten normal chocolate.



# 

VEN THOSE WHO didn't make it to Sunday school know what Noah's Ark looked like. And now a new Hollywood take, *Noah*, is compounding the myth. It was a long, pointy wooden ship with a large house built on the top, right? Well, no. At least if the British Museum's Middle East expert Irving Finkel is correct in his new book *The Ark Before Noah*. After painstakingly translating an ancient version of the great flood story found on a clay cuneiform tablet, Finkel discovered a set of instructions on how to build the ark. This was a spectacular find in itself, but the story gets even more intriguing: the craft described is round.

#### People know the flood story of Noah and the animals, but this tablet predates the Bible, doesn't it?

We've known that the Babylonians also had a version of the flood story since a curator here at the British Museum found it inscribed on another clay tablet in 1872. At the time it caused a great furore among theologians, Christians and Jews who knew their Bible. One of the most disturbing things for them was that the parallels between this 1872 discovery and the Hebrew text of the Bible were so close that it was difficult not to believe that the two narratives were connected in a literary sense. In the time since 1872, a sprinkling of other clay tablets of different periods have come to light, some big pieces, some only fragments. It culminated in this new one, which was written in about 1750BC, making it one of the oldest known.

#### Other than its age, what's so special about this particular tablet?

The central point of this tablet is the realisation that the boat the Babylonians conceived of was a round coracle. I don't think anybody



The 1750BC Babylonian tablet with a cuneiform description of an ark



would have expected that because if you read your Bible you will see that Noah's Ark was a sort of oblong wooden thing. So you have this very different, deeply established conception floating about in people's minds and so this boat comes across as a shock. It was a bewildering thing for a decipherer because, if you read the words on the tablet, you think: 'what the hell is this?'

#### Were coracles common during the time the tablet was written?

In ancient times, and in fact right up to the middle of the 19th Century AD, coracles were used in Iraq in huge numbers, and there are photographs from the 1920s where you can see a whole cluster of them by the side of the river. They functioned a bit like taxis. So if you wanted to cross the river, with a couple of sheep and your two daughters, you'd hire a coracle and the guy would get you across to the other side. And the thing about the coracle is that it is light, buoyant and thoroughly waterproof – to all intents and purposes it is unsinkable. Those are the qualities that Noah's Ark required. It

needed to be buoyant, but didn't have to go anywhere – as opposed to a boat with a bow and a stern, which could go on a specific voyage. All it had to do was bob around like a cork on the surface, until eventually the water went down. But what is peculiar and even more unexpected is that the tablet gives all the measurements, the quantities of the rope, the amount of bitumen, and how it was built. Also, the measurements that are quoted – which are very large indeed – are accurate.



A tablet inscribed with the story of the flood and ark from the 7th Century BC

#### So is this tablet instructions for a reader, or is it a description of something that actually happened?

Well, that is an extremely pertinent question. It is not obvious. As I see it, the flood story has its inception in reality inasmuch as the

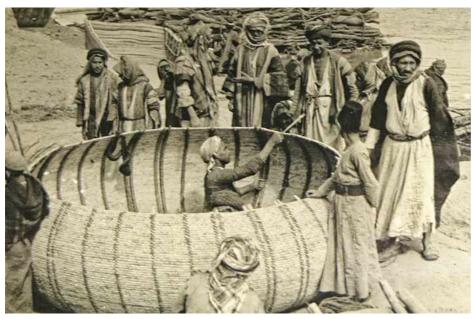
landscape of Iraq is fed by the great rivers and has always been vulnerable to flooding. There's lots of historical evidence for floods. I think the basic position is that the landscape of Iraq, or Mesopotamia, was subjected to a kind of tsunami a very long time ago in its remote past. Perhaps the bulk of the villages were swept away, down to the gulf, and knowledge of this was a deep-seated factor in their psychology.

The story itself went through mythological development. I think that the presence of what you might call the technical information, which looks as if it was a prescription for someone to go home and build one, was not that at all. As far as I understand it, the narrative of the floods – the anger of the gods, that last-minute rescue, the flood itself and the final revivification of the world – must have been in the purview of itinerant storytellers for a very long time. It's a classic, major strain of their mythology. We can tell from cuneiform literature that these stories circulated in that way before writing.

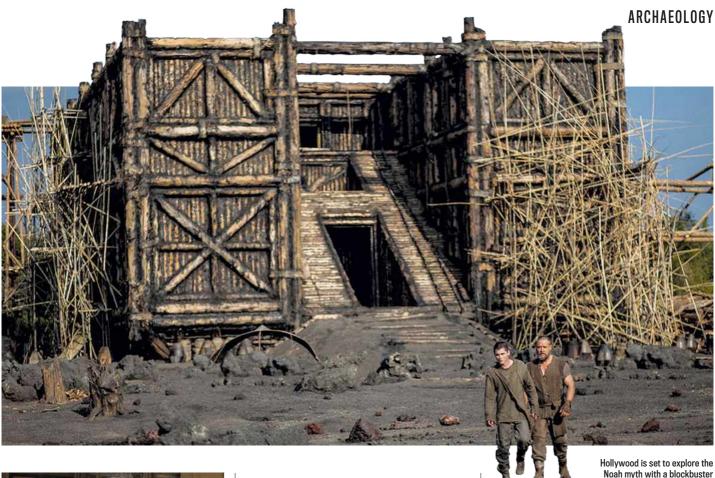
#### So why is the information so detailed?

My idea is that you have this narrative, with the divine intervention and the boat, being a central part of a very gripping story which is told to audiences who were primarily boatmen, fisherman and coracle builders. You might have a marvellous storyteller who could hypnotise a village with all of this 'Bruce Willis' drama, and then acts the part of the god with a thunderous voice and says: 'You will build this boat'. If he just said to these people build the biggest boat you ever saw', his listeners are going to say 'Well, what does it look like?' Once you had this question of 'what does it look like?' and 'how big was it?', it became a kind of itch for the storyteller and the audience.

I have the feeling there was a curiosity engendered about this. And it was probably solved in the following way: there could have been a schoolmaster who had half a dozen boys who were literate in the kind of calculations that professional scribes had to do, like how many bricks in a wall and so forth. At one point the schoolmaster said 'Everybody knows the ark is a round coracle, and let's say its surface area is 3,600m<sup>2</sup> and its walls are 6m high. How much rope do you need, if the rope is an inch thick?" This is exactly the sort of thing that we find on mathematical tablets; the sort of thing that scribes had to work out. The exact amount of rope needed was specified. In profile, a coracle is a bit like a doughnut, and if you have a plan of a doughnut with the height of the walls and the rope's thickness, you can work out how much rope you need.



A coracle being built in Iraq in the 1920s; they were used to taxi people and goods across rivers





Irving Finkel believes the ark was a round coracle

What is interesting is that in the version on the tablet found in 1872, which is much longer, the actual details about the components needed to build the ark are boiled down to a minimum. But I can't help but think that there was also a time during a build-up to the flood and the construction of an ark, when the design was actually full of specs that would have been very interesting to a coracle-builder. But as the story moved into perhaps more urban circumstances, and certainly into the capital of the Assyrian empire, nobody wanted to hear about all that stuff so it was squashed out of the story.

#### Could this super-large coracle have held several people and several animals?

A coracle that I've found in photographs has about 30 people on it, so you can build quite a big one. There's a documentary film being made in which specialists on ancient boats

are trying to build this thing on the basis of the ancient inscription. They have the materials and craftsmen to work with them, and they used computer modelling to consider size, strain and weight bearing. They rapidly came to the conclusion that if you made the boat to full size as described on the tablet, which is about half the size of a football pitch, it wouldn't work. It would simply be so huge that the structure wouldn't function. They reduced this size to the maximum scale that would work by using the tablet inscription and traditional building methods. I think it's somewhere between a third and half of the size.

#### So it's unlikely that any of the Babylonians actually tried to build this boat?

I don't think anybody tried to build this thing to scale in antiquity. I think you have a mythological theme of the ark that people normally accept without a lot of analysis. However, in the world of those living alongside boats, people might be a little bit more interested in the details than elsewhere. This led to the formalisation of it, but I don't think the audiences would ever to say to themselves, 'let's have a go at it'. They wanted something satisfactory conceptually.

#### Is it possible that anyone like Noah, or at least a Noah-like character ever existed?

In the Bible, it's clear that there was nothing but wickedness in the world and a single person, Noah, stood out as being the saviour. In the Babylonian world, the flood came because the human race was noisy, rather than sinful, and the gods were discomforted and irritated by the racket. That's a whole different framework, psychologically and poetically.

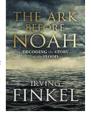
starring Russell Crowe

(foreground) out this month

It's a matter of taste whether you feel you need to retain a conception of Noah as a guy with sandals and a beard and a good sailor's gait, or whether you take the story to be a symbolic representation of the frailty of the human race in the face of God. It's about how the forces of nature and God's will can obliterate everything, and how sometimes a single man suffices to avert the wrath of God. That is a very powerful religious and philosophic precept, the potency of which has nothing to do with whether Noah was once in the world. When you know there was an equivalent to Noah a thousand years earlier, then it becomes even less important to establish. To me, the crucial thing is the potency of the story, and its unforgettable influence on the reader, which existed in Babylonia and was adopted

into the Bible with a different message.

IRVING FINKEL is an expert of the ancient Middle East at the British Museum and the author of The Ark Before Noah





# UTING SPACE

Life beyond Earth's atmosphere needn't be one swathed in a cumbersome suit with little movement. **Helen Cahill** checks out the latest in spacefaring gear

#### FLEXIBLE BIOSUIT

DAVA NEWMAN'S SKINtight space suit – the BioSuit – defies conventional aesthetics of astronaut attire. No more Michelin men bumbling across the surface of the Moon. The era of sleeker space-explorers has begun, and Newman envisages them rocketing to Mars in her form-fitting outfits.

NASA doesn't make its existing suit, the Extravehicular Mobility Unit (EMU), in a petite size, but Newman wants to enable women below 5ft 5in (1.6m), like herself, to explore Mars.

Her chief aim, though, is to give astronauts more mobility. Space is a vacuum, so the suit needs to provide the pressure astronauts require to stop their bodies expanding. The EMU uses gas for this purpose, which makes it an unbearably clunky contraption. Additionally, wearers are unbalanced by their weighty life-support backpacks.

Newman's team of physicists and designers propose a mechanical counter-pressure spacesuit, which uses elastic fabrics, rather than gas, to pressurise the astronaut. They are fashioning it out of spandex, nylon and a newly patented material. The uniform's pattern is from the supports that reinforce strain points on the body. These features help provide the required amount of pressure – about a third of sea-level atmospheric pressure.

"I'd love to see a BioSuit worn on the first human mission to Mars, or on a commercial space flight much sooner," says Newman.

#### 1 HELMET

The team is crafting a slim-fitting, gaspressured helmet. Astronauts will need to be able to look over their shoulders, which means creating an airtight joint between the helmet and the BioSuit's body.

#### ? RODY

Dr Karl Langer - a 19th Century anatomist - investigated and plotted the tension lines in human skin. His work inspired the pattern of reinforcing metal support-lines in the suit, marking critical strain points.

#### BACKPACK

A modular system so astronauts need only carry what they need and can quickly change bottles of oxygen on longer missions.

#### SPACE STATION SUIT

WHEN ASTRONAUTS aren't exploring the planetary landscape in their outdoor apparel, they're unwinding in the Space Station. Unfortunately, they literally waste away in their downtime. Muscles and bones need to counter gravity's pull to stay in shape - they deteriorate if unused. What's more, astronauts can grow by up to 7cm in space, as gravity is no longer loading their spine. Once they're back on Earth astronauts are then four times more likely to get a slipped disc.

To overcome these problems, teams at King's College London and MIT have designed this form-fixing skinsuit. "It essentially seeks to replace the compressive force of gravity on the body's length," says Dr David Green at King's College London. With straps around the feet, the elastic suit is intentionally made too short so that it stretches when worn, pulling your shoulders to your feet. The suit's leg fabric also extends more than the torso's, so your legs bear a larger force. This reproduces gravity's effect on Earth. "The force of gravity increases as you move down the body towards the feet," says Green.

Andreas Mogensen of the European Space Agency will be the first to don the outfit when he embarks on a space mission in 2015. If successful, UK astronaut Tim Peake may wear the suit when he goes to the International Space Station later in 2015.





#### **DOCTOR SUIT**

THE HEALTH OF our space-explorers is paramount if they're to make the 225 million kilometre (average distance) journey to Mars and step onto its rust-red surface intact. To keep them fit, a team at Kansas State University is developing smarter spacesuits – ones that can perform regular check-ups; a kind of wearable space doctor.

To do this, they're fitting sensors into spacesuits (pictured). The idea is that by monitoring their vital data, the astronauts can discern if they have the strength to perform a particular mission. This is

important because our bodies alter in space, and workers need to know how so they can do their jobs. They lose muscle mass and bone density, and visual acuity can deteriorate, possibly due to swelling of the optic nerve. The team is also creating a wireless network so the data-collecting gadgets can communicate with each other and a space station.

Using batteries to power these electronics in an oxygen-rich spacesuit would be dangerous, though. Instead, scientists want to use astronauts' body heat to provide energy. In space, people can't be cooled by air – through either convection or

Above: The medical space suit carries a raft of sensors, some of which can be seen being tested. Electrical sensors monitor muscle activity; accelerometers measure movement; sensors on the forehead, wrist or finger check oxygen levels in the blood and heart rate; and respiration belts worn on the chest measure breathing rate.

Right: A new energy-harvesting method (being tested here) uses the astronaut's body heat and cooling garment to power the space suit's electronics.

evaporation of sweat. So they wear a cooling garment, which consists of a layer that absorbs heat with fluid-filled pipes and a heat exchanger for removing energy from the circulated fluid. The researchers' cunning technology generates power using the temperature difference between this item of underclothing and the astronaut's body. ■

HELEN CAHILL is a molecular biologist and a writer for *Varsity* 



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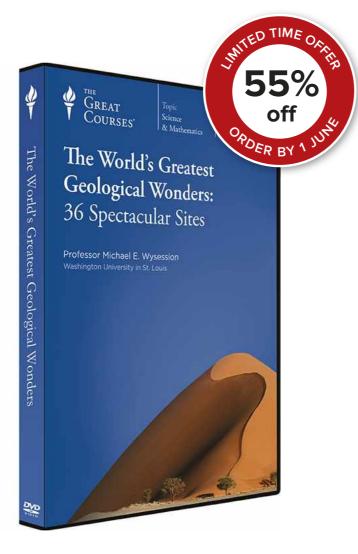


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- 18. Devils Tower—Igneous Enigmas
- 19. Antarctica—A World of Ice
- 20. Columbia Glacier—Unusual Glacier Cycles
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TERESA GAFFNEY, CINDERFORD

# What's the difference between steam and mist?



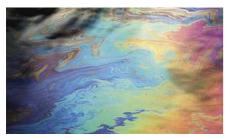
Water looks like it has misterious properties when airborne

A WATER CAN EXIST in three forms, or 'phases': liquid (running water), solid (ice), and gaseous – better known as steam. But contrary to popular belief, steam is invisible, as the water molecules in it are too hot to stick together in visible quantities. When they cool down they can stick together, forming mist. **RM** 

TOM STOREY, BY EMAIL

#### Is anything actually 2D?

NOTHING PHYSICAL CAN exist with literally zero thickness, as its atoms have a finite size. But there are many examples of so-called 'monolayers' just one molecule – or a few tens of billionths of a metre – in thickness. The most familiar are monolayers of oil in puddles, which are so thin they split light into its constituent colours. RM



A film of oil on water is able to split light into its colours

In Numbers

#### **91 metres**

(300ft) is the length of the longest aircraft. The helium-filled hybrid Airlander is being developed by a British company to deliver cargo and passengers.



A OUR BRAIN IS divided into two hemispheres with the left hemisphere controlling the right side of the body and the right hemisphere controlling the left. But the left hemisphere is also specialised for language. Language processing involves fine motor control and the ability to work with precisely timed sequences. Both of these things are also useful for manual dexterity. As we evolved sophisticated language, the

left hemisphere seems to have got better at co-ordinating the side of the body that it controls and so we tend to favour that side. The reason left-handedness hasn't been eliminated is that historically it gave you an advantage in hand-to-hand combat, against opponents expecting you to swing with your right. Left-handedness is only useful in this way when it is rare, so natural selection has held it at around 10 per cent of the population. **LV** 

GRAHAM BARNES. TICEHURST

## Why don't we eat turkey eggs?

A BECAUSE THEY ARE uneconomic to produce. Turkey eggs have a rich taste and work well in most recipes that use chicken eggs. They are much larger, with tougher shells, larger yolks and a higher proportion of yolk to white. Depending on the breed, they weigh from 65g (the size of a large chicken egg) to 110g. The problem is that turkeys can take up to 32 weeks to start laying and then lay only around 100 eggs a year. Chickens typically start laying within 20 weeks and produce about 300 eggs a year. This is because they've been bred to turn food efficiently into eggs but turkeys have been bred to produce meat. It would be quite possible to breed turkeys for egg production, but at the moment you are likely to be able to buy them only from specialist producers and bird rescue farms. SB



Luckily for the turkey, its eggs are too expensive to produce, but its luck runs out come Christmas



a nearby object in a different

background. Similarly, nearby

position when viewed on each

side of the Earth's orbit (every

six months). Armed with the

Sun-Earth distance, which is

positions of the inner planets,

these shifts in position reveal

For stars too far away to

use this 'parallax' technique,

astronomers rely on a simple

the star's distance.

measured by looking at the

stars undergo tiny shifts in

position relative to the

principle – if you know exactly how intrinsically bright a star is, then measuring how bright it appears to us on Earth will reveal its distance. Some stars vary in brightness and the time taken for these variations is directly related to their actual luminosity. The intrinsic brightness of some exploding stars can also be worked out by looking at their evolution. Objects of this kind, with known brightness, are called 'standard candles' and are the main tool astronomers use to determine distance to other stars. AG



O CAREL LUCAS, PERTH, AUSTRALIA

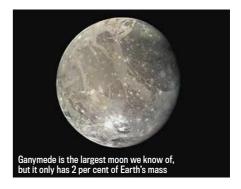
# Why does hair get darker when wet?

WHEN LIGHT STRIKES dry hair, some of it is absorbed by the pigment in the hair and some reflects back to your eyes. Water is transparent and a thin film absorbs very little light by itself. But when light hits wet hair, some of the light reflecting off the surface of the hair strikes the inside surface of the water film at the right angle to be reflected or refracted back onto the hair again. This creates a second chance for the light to be absorbed, making the hair appear darker. LV

PAUL BILLANIE, BY EMAIL

# Could an Earth-sized moon exist?

A IT APPEARS THAT the usual process of moon formation, by 'accretion', is not efficient enough to produce moons more than 0.025 times the mass of Earth. This explains why Jupiter's moon Ganymede, the largest moon in the Solar System, is only 2 per cent of Earth's mass. But there are other ways planets can gain moons. A large planet could disrupt a binary system of two Earth-sized planets, ejecting one but capturing the other as a moon. AG



#### 9,000m

is the height that alpine bumblebees were shown to be able to fly in an experiment. It means they could fly over Mt Everest, despite the thin air.

**CHRIS MENZIES**, CARDIFF

# Will spam ever slow down the internet?



You'd be stupid to click this!

A FIGURES from information security firm Symantec say that 68.8 per cent of all emails are spam. But that alone is not enough to slow the internet.

Cloud security firm, Incapsula reckons that botnets drive 61.5 per cent of web traffic. These networks of hijacked computers are used to blitz servers through so called DDoS attacks. Individual networks can be incapacitated for a while, but the internet is a network of networks. Slowing it is virtually impossible. **GM** 

ROY BEDFORD. WEST YORKSHIRE

# What does a wide tree ring mean?

A TREES GROW BY adding new cells just under the bark, increasing their diameter. In spring they grow faster than in late summer and autumn, and in winter they generally don't grow at all. The distance between rings shows how good the conditions were that year. Wider rings usually mean warm, wet summers. LV



Tree rings are a window into past weather conditions

Can you be harmed by solar radiation at the north/south poles?

THE MAGNETIC FIELD deflects most of the high energy particles from solar wind and cosmic rays before they reach Earth. At the magnetic poles, these particles slip through, but they mostly only get as far as the upper atmosphere before being absorbed. At ground level, your radiation exposure is no higher at the poles than on the

equator. But in the air it's a different

story. Flights between the USA and

Asia now routinely fly over the North

altitudes, the air is thin enough to let

some cosmic rays reach you. On an

Pole to save fuel and, at typical cruising



ordinary flight over the poles you might

receive 12 per cent of your recommended

radiation limit for the year, and during a

annual radiation limit in a single flight. LV

solar storm you can exceed your entire



# INVELOX WIND TURBINE

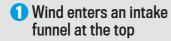
1.

THE SIGHT OF towering turbines springing up in the country may soon be a thing of the past. Those rotating monarchs of wind-based renewable energy need blustery gusts to function. However, a new, unobtrusive wind harvester, the INVELOX, can generate electricity with breezes blowing as slowly as 3km/h (2mph). So how is this feat achieved?

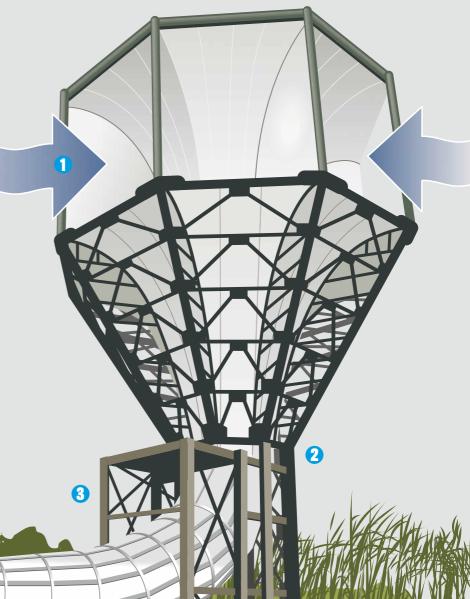
The key to this green machine is its tapering design, which squeezes wind collected at its mouth through a succession of nozzles and pipes. Fluids, unlike traffic, must speed up as they flow through a constricted cross-

sectional area, something known as Venturi effect. INVELOX's intake-winds going at 16km/h (10mph) can reach 64km/h (40mph) at the turbine – indeed, its name comes from a 'dedication to INcreasing the VELOcity of wind'. Consequently, the kinetic energy rises too and turns a generator, yielding electricity.

The company behind INVELOX, SheerWind, claims it makes 600 per cent more energy than current systems, leading to the prospect of bladed generators being replaced by this less conspicuous alternative. Having successfully tested it, the company is now taking orders.



- 2 It's channelled to pick up speed
- 3 Venturi effect increases velocity of wind
- 4 It drives a turbine
- **5** Wind leaves the system



#### TOP TEN

#### SMELLIEST CHEESES

The cheeses were judged by 19 members of a human olfactory panel and one electronic nose at Cranfield University.



#### 1. Vieux-Boulogne

Ingredient: Cow's milk Origin: Boulogne-sur-Mer, France Age: 7-9 weeks



#### 2. Pont-l'Évêque

Ingredient: Cow's milk Origin: Normandy, France Age: 6 weeks



#### 3. Camembert de Normandie

Ingredient: Cow's milk Origin: Normandy, France Age: minimum 3 weeks



#### 4. Munster

Ingredient: Cow's milk Origin: Alsace-Lorraine, France

Age: 3 weeks



#### 5. Brie de Meaux

Ingredient: Cow's milk Origin: lle de France Age: 4-8 weeks



#### 6. Roquefort

Ingredient: Sheep's milk Origin: Roquefort-sur-Soulzon, France Age: 3 months



#### 7. Reblochon

Ingredient: Cow's milk Origin: Haute-Savoie region, France Age: 3-4 weeks



#### 8. Livarot

Ingredient: Cow's milk Origin: Normandy, France Age: 3 months



#### 9. Banon

Ingredient: Goat's milk Origin: Provence region, France Age: 1-2 weeks



#### 10. Époisses de Bourgogne

Ingredient: Cow's milk Origin: Burgundy, France Age: 4-6 weeks **Q** ELLA HUMPHREY, READING

#### Why do birds fly in formation?

MANY BIRD SPECIES fly together in V-shaped formations, and naturalists have long suspected this has something to do with aerodynamic efficiency. The truth has now been uncovered by researchers after fitting flocking birds with tiny data-loggers. In research published recently in *Nature*, a team led by Dr Steven Portugal of the Royal Veterinary College, London, show that birds are indeed arranging themselves into the most aerodynamic – and thus least exhausting – formation.

It turns out the V-shape is best for exploiting the upward-moving air generated by the preceding bird in the formation. This reduces the amount of lift the next bird has to create itself, enabling it to conserve energy. The birds even adjust the rhythm of their flapping to make the most of the effect.

Birds that fly in a line behind one another aren't stupid, though: they've opted to avoid the downwash of those ahead of them, again deliberately altering their rhythm to minimise the loss of lift. **RM** 



TIM REES. LYMINGTON

# What's the record for the longest-running machine?

A THE LONGEST RUNNING machine is very likely to be a clock. The oldest one still going is the Medieval clock in Beauvais Cathedral in northern France, claimed to date back to 1305. Salisbury Cathedral boasts a clock from 1386. Both have run almost continuously.

The oldest working internal combustion engine is the Otto Langen serial number 1. It was built in 1867 and is still cranked up in its home, the Technikum Engine Museum in Cologne in Germany. Though not strictly a machine, the 'Centennial Light' also deserves a mention. It is an incandescent light bulb that has been lit almost continuously since 1901. It has a carbon filament that glows bright yellow within an evacuated hand-blown glass bulb. The bulb hangs in a fire station at Livermore in California. **GM** 



The Medieval clock in Beauvais Cathedral is still going

CAROLINE STEPHENS, HULL

#### Are growing pains medically recognised?

A YES, BUT ONLY as what is called a 'diagnosis of exclusion'. In other words, if a child complains of recurring leg pain at night and no medical condition is found, a doctor may blame 'growing pains'. About one in four children experience them, often when aged three to five, or eight to 12. The pain comes in both legs

in the evening or during the night, often after a particularly active day, and can be in the thighs, calves, or shins but not in joints.

Since there's no good evidence linking the pains to growth, some experts prefer to call them 'recurrent nocturnal limb pain' or 'benign leg ache in children'. **SB** 



It's no pain no gain for one in four children

**Q GEOFF DUNWELL.** MAIDENHEAD

#### Which species collectively takes up the most space?

THE FURTHER UP the food chain an organism is, the larger each individual tends to be, but the smaller the total weight for the whole species. That's because not all the food an animal eats is turned into body mass; some is used to drive the metabolism. Blue whales, for example, weigh about 150 tonnes each but there are only about 10,000 of them so their total weight is only about 1.5 million tonnes. The Atlantic krill that they eat are just a few centimetres long but collectively they

weigh more than a hundred times as much as the total mass of blue whales. The plankton that the krill eat probably outweigh them by a similar margin, but they comprise lots of different species so the 'per species' weight is lower.

But if you consider the *space* that a species takes up, rather than its simple biomass, it's possible that humans would rank top. Around 0.5 per cent of the total land area on Earth is urban land and while other species share that land with us, the biodiversity

in cities is much lower than in the countryside. When we build a city, we claim that space for ourselves and keep other animals out much more effectively than other animals do with their own territories. Half the world's population lives in towns and cities now, so the 750,000km² of urban land equates to 214m² per person. This means a city dweller takes up about twice as much space as a blue whale. And there are 350,000 times more of us. **LV** 

We humans like to spread ourselves out - more so than any other animal on Earth





**Q** ALAN HATCHARD, BRISTOL

# Why don't prey animals have eyes in the backs of their heads?

ANIMALS NEED TO know where they are going, so they must have eyes that look forwards. If they also had eyes on the backs of their heads, the brain would have to combine these two totally different views into one, including opposite directions of movement. A simpler solution, found in many prey animals, is to have eyes on the sides of the head to give a very wide field of view. Rabbits, for instance, have eyes high up on the side of the head. The disadvantage is a small blind spot right in front of them. Goats, however, have horizontal pupils that allow them to see 320° with no blind spot. \$\mathbf{SB}\$



The goat's horizontal pupils let it see to the side and front

**DEN HASKETT, SHERBORNE** 

# Would a tardigrade survive passage through your gut?

THESE MICROSCOPIC ANIMALS have a well-deserved reputation for extreme toughness. To protect themselves they can transform into a barrel-shaped cyst called a 'tun'. In this state they can survive temperatures as high as 151°C or as low as -272°C and very long periods without air or water. Their resistance to acid is less well documented, but a 2005 study at Columbus State University found that they were unaffected down to at least pH 3, which is almost as acidic as your stomach. Assuming they survived that, the trip through your intestines would be a breeze. LV





O DANIEL BURGESS, SHEFFIELD

#### Why does honey crystallise?



M HONEY IS A supersaturated solution of glucose and fructose. This is inherently unstable and so it naturally tends to crystallise over time. Glucose is less soluble than fructose so it crystallises first. Honey made from plants with higher glucose content in their nectar

(including dandelions and rape) crystallises more quickly.

Commercial honey is heated and filtered to remove tiny crystals and pollen grains that act as seeds for crystal growth, so that it stays liquid for longer. Storage temperature is a factor too. Honey crystallises quickest between 10°C and 15°C. LV

# WHAT IS THIS? WHAT IS THIS? KNOW THE ANSWER? Go to science focus.com/qanda/what and submit your answer now! LAST MONTH'S ANSWER: Jonathan Lodge correctly guessed

Mount Everest from space

**O** ANTHONY CARTER, FIFE

# If you bang yourself, why does rubbing the area help the pain go?

A) IT SEEMS THAT how much you think about pain has a big effect on how much it actually hurts. When you rub your banged shin, you are stimulating a different set of nerves and this gives you something to focus on other than the signals from the pain receptors. There may also be an illusory correlation at work. Most bangs only hurt acutely for a few seconds. If we spend those seconds rubbing the bashed part, we are likely to believe this is what got rid of the pain. LV



SAM WINSTON, MANCHESTER

#### What is nanocellulose?



A magnified view of the wonder material nanocellulose

A CELLULOSE MAKES UP cell wall. Nanocellulose is made from fibres of natural cellulose extracted using a chemical technique called acid hydrolysis. The resulting material is strong, flexible and lightweight. In future it could be used in everything from body armour to membranes for purifying water. With extra processing, it can take on electrical properties and could be used in flexible phone displays. **GM** 

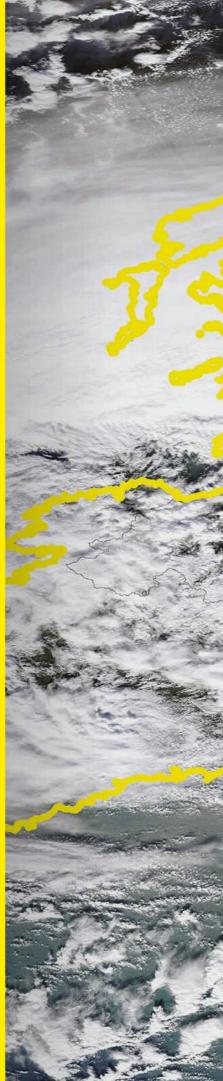
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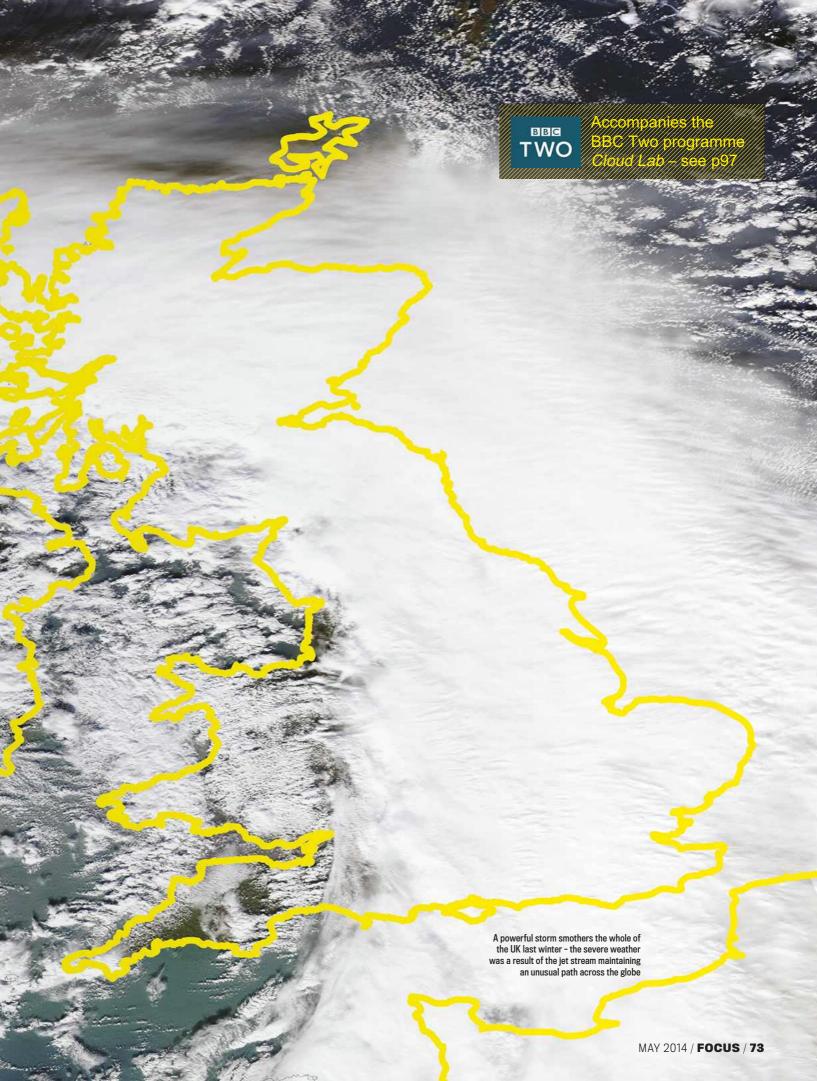


For even more answers to the most puzzling questions, see the Q&A archive at www.sciencefocus.com/qanda

# HAS OUR WEATHER GHANGED

After biblical floods, warm winters and soggy summers, **Paul Simons** reveals how the jet stream is wreaking havoc with our weather and asks if the wild conditions are here to stay









HIS WINTER WAS terrifying.
Britain was pounded by
relentless storms, torrential
rain and floods of biblical
proportions for months.
Nothing quite like it had been
seen since records began.
Meanwhile, across the Atlantic,

half the US was frozen in an Arctic hell, while California suffered record heat and drought. Alaska's weather was so mild it set off floods and avalanches. The rest of the world suffered too; Saudi Arabia was flooded, northern Iran had its worst storms for 50 years and Tokyo broke its snowfall record.

The culprit is the jet stream, a river of fast-flowing wind several kilometres high that swept around the globe delivering violent weather. Scientists are now piecing together what drove it to this point and whether it's likely to happen again. And what role, if any, does climate change play in disrupting it?

The jet stream is fuelled by a massive collision between cold air from the Arctic and warm tropical air from the equator. When these two air masses clash it creates

powerful winds, especially in the upper reaches of the atmosphere where there's less friction to hinder their speeds. In fact, at altitudes of 11km (7 miles), the jet stream travels at speeds of 160-320km/h (100-200mph) and is often hundreds of kilometres wide. And the greater

# "Clearly something was cockeyed with the global weather system to produce such weird patterns"

the contrast between the cold and warm air, the greater its speed. The spin of the Earth sends the jet stream eastwards, but it can also snake north and south in great loops, and where the jet stream goes it takes lots of weather with it. Over the UK its course had locked into position for months, wreaking havoc.

In Britain, the jet stream has only recently attracted headline news – which is surprising because it exerts a considerable stranglehold over our weather. And when the jet stream shoots across the Atlantic at speed towards the UK, it drives storms along like an

overhead conveyor belt that can blast the country with wind and rain.

But in recent years the jet stream has been buckling into huge kinks that have become stuck for weeks and months on end. This winter was a classic case, as the jet stream looped up high over northwest America around Alaska,

then swung towards Florida. It then bent north across the Atlantic towards the UK and Western Europe, dragging warm wet tropical air that helped fuel devastating storms and flooding rains, but also kept the weather remarkably mild. That wavy pattern persisted for the entire winter. "Usually the jet stream shifts over days or weeks, but the



# **HOW THE JET STREAM CHANGED THE COURSE OF HISTORY**

Extreme weather proved decisive in World War II



Finnish troops patrol their borders during the bitterly cold winter of 1939, conditions that would help them defeat the Red Army

THE JET STREAM is a river of wind circling the globe eastwards at speeds of around 320km/h (200mph) - which is why aircraft flying from New York to London can go much faster and save fuel if a pilot rides the jet stream over the Atlantic. If the jet stream travels directly over the UK, that usually brings mild wet winters and cool damp summers; but if the jet stream passes to the north or south it generally delivers cold. dry winters. These winters can be exceptionally cold, like that recently experienced in the United States.

So powerful is the jet stream's influence it can even help change the course of history. In the 1940s, the jet stream swung much further south and created brutal winters during World War II. In the winter of 1939-1940. Russia invaded Finland but was totally unprepared for an exceptionally cold winter and suffered massive casualties at the hands of the tiny Finnish army, which was well equipped for winter warfare. But when Germany invaded Russia in 1941, the Germans were also unprepared for another intensely cold winter, leading to huge casualties that arguably helped the Russians defeat them.

amazing thing about this winter is that it didn't shift. It persisted in the same position, that was the really striking thing," says Sir Brian Hoskins, director of the Grantham Institute for Climate Change at Imperial College London.

# THE PERFECT STORM

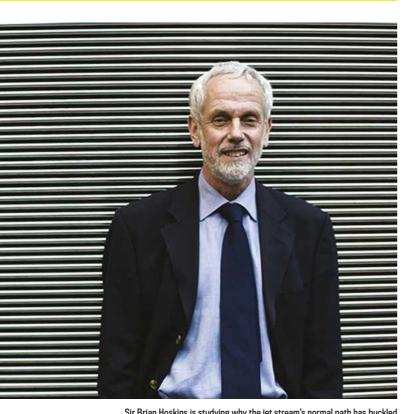
Clearly something was cockeyed with the global weather system to produce such weird patterns, and serious detective work by meteorologists at the UK's Met Office finally unravelled the mystery: a perfect storm as the Pacific Ocean and the stratosphere drove a fast and buckled jet stream around the globe.

The seas in the western Pacific were unusually warm, billowing up warm air into beefy rain clouds that unleashed flooding rains over Indonesia. That warm wet rising air also sent ripples out through the atmosphere. "It's like dropping a rock into a pond, sending waves rippling out from the tropics into the higher latitudes," explains Adam Scaife at the Met Office Hadley Centre. "Those waves helped to buckle the path of the jet stream towards the Aleutians off the west coast of America. Everything downstream of that was then locked into a weather pattern all winter."

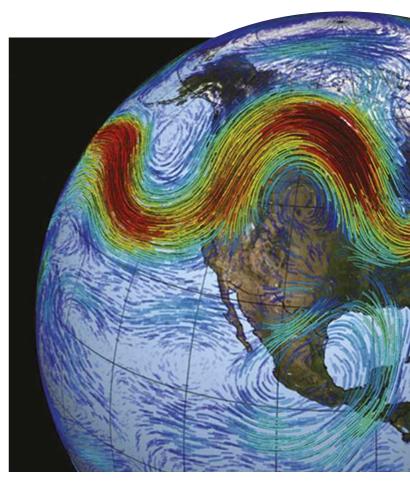
And there was also trouble in the stratosphere, 32km (20 miles) high. Winds in the stratosphere race around the tropics, but every 14 months or so they suddenly switch direction and this winter they blew eastwards, the same direction as the Atlantic jet stream. They reached double their usual speed and supercharged the jet stream lower down in the atmosphere. It reached record speeds, around 400km/h (250mph) over the North Atlantic, making storms explode into a frenzy as they tore across the UK and Western Europe.

But the dual attacks of the Pacific Ocean and stratosphere can't explain the crazy weather Britain has suffered over the last few years, lurching from floods to droughts, freezes to heatwaves, storms and tornadoes. Hardly a month goes by without a record broken: December 2010 was the coldest for over 100 years,









# **HARNESSING** THE POWER OF THE JET STREAM

The radical designs that could tap into this abundant source of energy

HIGH-FLYING WIND turbines have been proposed to tap into the jet stream's powerful winds, providing an immense source of energy. One proposal is for big floating balls rolling in the wind, another is for high altitude kites that could power generators. Another idea is a helicopter-like generator carried by four huge rotors flying 5 miles (8km) high; a tether made of aluminium cable would carry power to the ground and help to keep the device in place (pictured).

However, there are huge challenges in keeping control of the high-flying turbines, avoiding airspace for aircraft, and also keeping track of the fluctuations in the path of the jet stream.



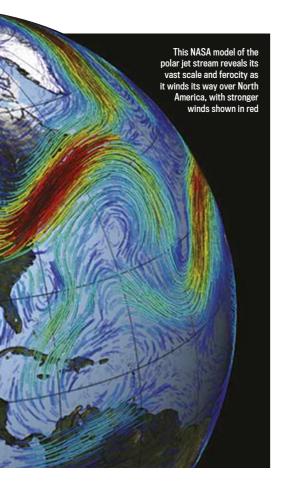
Airborne wind power generators like these could be used to harness the fast-moving winds of the jet stream

England had its wettest year on record in 2012, the coldest March for 51 years in 2013, and so it goes on.

The weather has also been extreme across the globe. In the summer of 2010 the jet stream made a very unusual and strong buckle down into Pakistan and hit the monsoonal rain belt with catastrophic results. The jet stream supercharged the monsoon rains, which drenched the highlands of Pakistan and triggered flooding on a colossal scale. It left a fifth of the country under water and around 2,000 people dead.

Why the jet stream buckles so violently is not always clear. Some of it may be down to chaos in the Earth's climate. but there are also other forces at work. "We've now identified a number of factors that can effect the positions and strength of the jet stream. In Britain the winter jet stream is affected by things such as El Niño and La Niña, fluctuations in the Gulf Stream in the Atlantic, volcanic eruptions, solar activity, and the winds in the stratosphere," says Adam Scaife.

The path of the jet stream also seems to drift over the decades. In the 1960s it was weak and shifted south, and that gave Britain a run of bitterly cold winters. In the 1990s the jet stream shifted north



# DISCOVERY OF THE JET STREAM

The finding that balloons drift at high altitude was soon put to an unusual use

JAPANESE METEOROLOGIST WASABURO Oishi discovered the jet stream in the 1920s when he found that high-flying weather balloons swept eastwards on strong winds, even in clear weather. To get maximum publicity he published his findings in Esperanto, the international language, but no one read it. However, when World War II broke out, the Japanese military realised the jet stream could float balloons loaded with bombs and reach America - something no aircraft could do. The intention was to set fire to the forests of the western USA and cause mass panic. But of 9,000 'Fu-Gos' launched only 300 reached America and the forests were too wet to set alight, although six people in Oregon were killed by a Fu-Go explosion.



A Japanese fire balloon - the weapon made its way to the US from Japan by hitching a ride on the jet stream

and gave a run of mild and wet winters. However, there is little evidence that the jet stream is taking a permanent lurch north or south; instead, it may be wandering in tune with natural rhythms

# "Why the jet stream buckles violently is not clear - it may be down to chaos in the climate"

deep inside the Atlantic Ocean.

"A rapid warming of the North Atlantic Ocean that occurred in the 1990s coincided with a shift to wetter summers in the UK and northern Europe and hotter, drier summers around the Mediterranean. It was a similar story in 2012 when the UK had the wettest summer in 100 years," explains Rowan Sutton, Director of Climate Research at Reading University.

This still doesn't explain why the jet stream has stuck into such weird contortions in recent years, though according to Brian Hoskins, the Director of Climate Science at Imperial, we are seeing the jet stream buckling into a number of persistent patterns, different from the norm. But we can't tell why yet

- and that could be the most important thing. It's tempting to point the finger of blame at climate change. Jennifer Francis, a Research Professor at Rutgers University, New Jersey, has suggested that the warming Arctic could be to blame, where the icecap is melting at an alarming rate. It is creating a feedback loop that further increases Arctic

temperatures, a process known as amplification. However, a warmer Arctic should make the jet stream weaker, because there's less of a battle between cold and warm air driving it. There is no clear-cut evidence that climate change is having much impact on the jet stream in any other way.

"There's a lot of misinformation around," warns Adam Scaife from the Met Office. "These are big impacts but no systematic shift of the jet stream has been found so far, so it is hard to relate this directly to climate change. The waviness of the jet stream also looks variable rather than trending in any single direction."

This is a hot topic of research, but it needs agreement between the computer models of the world's climate and real observations of the weather – only then can we be confident that the jet stream is changing, and so far that evidence is lacking. "The climate computer models are very successful in spontaneously reproducing the jet stream and they show realistic fluctuations from year to year. But when we add CO<sub>2</sub> to the models we don't see a big increase in waviness, or a big increase in storminess like we have had this winter," adds Scaife.

However, what is truly exciting is that we are getting closer to predicting where the jet stream lies each year, which will give important clues to the coming seasonal weather. A recent Met Office forecast for the North Atlantic is that it is about to cool and possibly change the jet stream over the next few years, moving it northwards. In which case Britain can expect more mild winters and hotter summers than we've had in recent years.

PAUL SIMONS writes the Weather Eye column for *The Times* 

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# THE FUTURE OF GADGETS

# 

# ◆ THIS MONTH

BILL THOMPSON The 5G car network p81

JUST LANDED
DJI Phantom drone
p82

ULTIMATE TEST Telepresence devices p84

EDITED BY DANIEL BENNETT

**ON THE HORIZON** 

# **AURORA DREAM-ENHANCING HEADBAND**

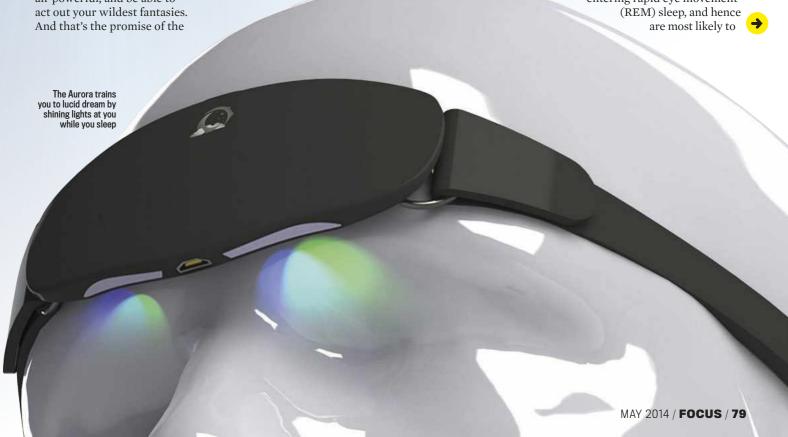
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UR DREAMS MAY seem strange, bizarre, and even scary at times, but imagine if you were able to take control of them, and actually influence what went on. You'd effectively become all-powerful, and be able to act out your wildest fantasies. And that's the promise of the

iWinks Aurora Dream-Enhancing Headband.

The people behind it say that it helps you lucid dream - this is the state where you become aware that you're dreaming. It might only happen for a couple of seconds at first, but with persistence you can train yourself to extend this, and to become more aware while you dream. And the more aware you are, the more you can take control of what's going on.

Here's how it works. You strap on the iWinks Aurora headband and settle down for a night's kip. The Aurora watches you while you sleep, so it knows when you're entering rapid eye movement (REM) sleep, and hence are most likely to





dream. It monitors your brainwaves and eye movements, and uses an accelerometer to tell when you're moving least and hence in deep sleep.

Once you're fully under, the Aurora goes to work. It plays a series of flashing lights and sounds that appear in your dream. When you recognise them, you become aware that you're dreaming, and hence can take control, and start doing what you want. That's the theory, anyway.

There are some caveats. This device is no guarantee you'll be able to lucid dream. Some nights you might not even enter REM sleep. Even if you do, there's a chance the lights and sound will wake you up, rather than make you aware you're dreaming. But the Aurora is more advanced than most rival devices.

For a start, you can customise the lights' colours and flashing patterns, and adjust their brightness. So if you're a light sleeper you can set them low so they're less likely to wake you up. The Aurora also detects when you enter REM sleep and kicks in then, whereas some previous devices just take a guess, which is usually off the mark. It connects to your smartphone wirelessly over Bluetooth

too, so you can insert your own sounds into your dreams.

Still, some experts are sceptical. Ian Wallace is a dream psychologist and author of *The Top 100 Dreams*. He says the Aurora will be a bit hit and miss. "If learning to lucid dream is like riding a bike, then this device is like training wheels," he says. "Getting the right light intensity will take a bit of trial and error, especially as how lightly you sleep varies from night to night."

But he stresses it's no replacement for the proper mental preparation. "The key thing with lucid dreaming is you need to train yourself psychologically, and a device like this can't replace that. The Aurora may help, sometimes, but don't expect it to do all the work for you."

It might not be quite the wonder gadget we hoped for, but it is still one of the most advanced of its kind. As for a device that lets us take full control of our dreams every single night without fail, we'll have to keep dreaming.

JOE SVETLIK is a freelance technology journalist and news reporter for CNET

# TECHOMETER

# WHAT'S HOT BATTERY-FREE ELECTRONICS

Scientists have found a way to harvest TV signals and turn them into electricity. University of Washington researchers have created a prototype called AllSee that generates electricity from wireless signals. It's also able to translate any interference in the broadcast signal it collects into gesture commands. For example, if you wave your finger across the back of the device it alters the wave signal in the air. The AllSee recognises this distinct interference and associates it with a command - like putting your phone into silent mode.

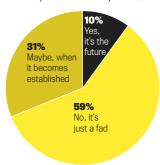
# WHAT'S NOT

**BITCOIN** 

Digital banks holding the crypto-currency Bitcoin have been hit by a spate of robberies. Flexcoin, the self-described 'first bank of Bitcoin', shut its virtual doors after hackers stole \$600,000 (£360,000) from its 'vaults' last month. Before that the world's biggest Bitcoin exchange, Mt. Gox, filed for bankruptcy after \$500m (£300m) was stolen. If the currency, which is bought and sold online and isn't linked to any central bank or government, is to become mainstream, it will have to address its security flaws.

# READER POLL

Would you invest money in Bitcoin?



# THE NEXT BIG THING

# THE 5G CAR NETWORK

ORMULA ONE racing – I've never seen the appeal. However, I don't mind it as much as some sports because it's not so much a competitive activity as the very sharp end of engineering research. The innovations in engine design, fuel economy, safety and aerodynamics that come from getting cars to go really fast around circuits have an impact on the way cars are built. This includes their increasing reliance on computers: modern cars are packed with processors for engine management, tracking and driver information because race car designers saw their capabilities and wanted to use them.

Now it seems the innovation pathway is going to be reversed, and the needs of car designers might have a significant effect on the way we design the next generation mobile networks. It's happening because in order to deliver the promise of safe, reliable self-driving vehicles we're going to have to make fifth-generation cellular systems work a lot better even than 4G.

Phone company Ericsson recently started working with network provider AT&T and car company Volvo to launch what they call a 'Connected Vehicle Cloud'. It's a system that puts your car online, enabling it to deliver news and traffic information, as well as car telemetry, so that your vehicle can schedule its own servicing.



However, the real goal is to go much further and have the car use the connection to provide real-time warnings and do things like brake safely in an emergency, or even drive itself like the Google cars.

Speed – whether that of the car or the network – isn't the real problem here. We know 5G will be faster, because we're good at making networks faster. The real issues are about reliability and latency (response time), because if we're going to make a car just another node in the connected, cloud-based world then we need to rely on predictable connectivity.

Making this happen is a real challenge for network designers. You need a very reliable connection, but you also have to deal with network latency and service quality. It's annoying enough when you get shot in *Halo* because someone else in the house starts streaming YouTube on their phone, but having your car weave into traffic because the kids are playing *Minecraft* in the back seat would be a lot worse.

Nobody expects this to happen quickly, and it will be the turn of the decade before we see working 5G networks being deployed, but it seems that in-car connectivity is now one of the design goals for next generation vehicles.



BILL THOMPSON contributes to news.bbc.co.uk and the BBC World Service

# **COMING SOON**

# 3 MONTHS

# **SAMSUNG GEAR 2**

Samsung has improved its next model of the Galaxy Gear smartwatch. It uses a faster OS called Tizen rather than Android, is slimmer and armed with a better processor. Samsung.com

### + iRobot

If you're considering a robot cleaner, it might be worth waiting. iRobot will upgrade its line of household 'bots this summer. *iRobot.com* 

\_\_\_\_\_

### + Instacube

This digital photoframe plucks pictures from Instagram and, with a future update, Flickr and Facebook accounts. *Goinstacube.com* 

## 6 MONTHS

# **APPLE CARPLAY**

Apple is bringing iOS to cars in the shape of CarPlay. It'll be loaded with Siri too, so it'll read out text messages and respond to voice commands. *Apple.com* 



### + Android 6

Google's next OS is rumoured to be optimised to work with different wearable gadgets, like Google Glass. *Play.google.com* 

### + Moverio

These smart specs use projectors to create images on each lens, making the display easier to see than on Google Glass. *Epson.co.uk* 

# 9 MONTHS

# 2014 FORD MUSTANG



The 2014 Mustang has learned some new tricks for its transatlantic crossing. It'll have a frugal, but powerful, EcoBoost engine, self-parking, and will drive itself out of the way if you're about to have a collision. Ford.com

### + Pebble

The standard-setter in smartwatches will release another model before the year's out. With its blossoming app support, we can't wait to find out what's in store. *Getpebble.com* 

### + Apple iPhone 6 and a smartwatch?

The world's most popular smartphone is due a redesign in October. Rumour has it Apple will introduce a companion smartwatch for its next phone. *Apple.com* 



# SKYTV

The era of the personal drone is upon us. **Daniel Bennett** flies a roving camera

# What is it?

Technically speaking it's an Unmanned Aerial Vehicle (UAV). But to you and me a it's a toy for grown-ups, albeit one that could be useful.

### So what does this drone do?

Aside from putting a massive smile on your face, this quadcopter's main job is to play cameraman. It has a small, wide-angle HD video camera attached to a mount that dampens vibrations, keeping your footage smooth and level. The Phantom creates its own long-range (300m) Wi-Fi signal over which it sends a live view from the camera straight to your smartphone. Fly too far away and the drone zooms back to the last GPS location it logged. Hit record and it can capture video and still pictures.

# What's it like to fly?

Unlike remote-controlled helicopters of yesteryear, you don't need to read a 400-page manual to get the Phantom off the ground. A friendly 16-step guide gets you up in the air quickly - though we tipped it into the ground

Phantom 2 Vision, €1,072.45 (£896),

on our maiden voyage, turning one of the blades into splinters. Thankfully, the drone comes with spares, and replacement blades are inexpensive. In the air, accelerometers, gyroscopes and a compass keep the whole thing steady, regardless of your piloting skills. Going forwards, the Phantom can reach speeds of 15m/s, more than enough to keep up with Usain Bolt, and it can climb at 6m/s. Traditional controls paired with a diagnostic-filled live view on the smartphone (pictured inset) make piloting the drone a breeze. The 25-minute battery life means the fun is over before you know it, but it's still an impressive feat when you consider how much the Phantom is doing.

1111

### Should I buy one?

need to visit YouTube

to see the proof.

If you fancy yourself as a drone cameraman or woman – yes, that's a real job – then there's no better way to start. For great, rather than good, video it's worth buying a separate GoPro Hero camera. This will give you the kind of film you'd see in a BBC nature documentary. If you're just after a toy then consider the Parrot AR.Drone. As a filming tool, though, the Phantom is unmatched. You just

# FLY ME TO THE DATA

# Three ways scientists are using drones to get closer to nature



# Volcano inspectors

Photographer Shaun O'Callaghan used his DJI Phantom to film an active volcano in the South Pacific. It's inspired scientists to start using UAVs to monitor the activity of other volcanic regions. bit.ly/PhantomVolcano



### **Dolphin trackers**

Drones can get close to the water without disturbing the wildlife, so marine biologists are using them to track whales and dolphins, including one Phantom owner who filmed a rare dolphin stampede. bit.ly/DJIDolphinStampede



### Weather forecasters

Titan Aerospace is currently testing a solarpowered UAV called Solara 50 that will fly for five years non-stop. Its goal is to track hurricanes and weather systems around the world. bit.ly/Solara10













# **APPLIANCES OF SCIENCE**

# 1 SMARTER SOUNDS

About 20 per cent of the 20 million songs on Spotify have never been listened to. In the case of 'Gregorian Chants: Songs of the Beatles', that's not such a bad thing. But how can you unearth those potential favourites? The Cone speaker streams music from the web and learns what you enjoy to bring you new music. Listen to a track all the way through and it will play more songs like it. Skip and it'll dodge it in future.

## Cone

\$399 (£240) plus P&P, Aether.com

# 2 DRONE DRIVING

Your next car could have its own flying drone if this concept from Renault is anything to go by. The idea is that the car's autonomous quadcopter could scope out the journey ahead with its on-board camera and report back on any traffic or accidents. Alternatively, if you're stuck in a jam you could pilot the drone yourself, but if your flying ability is anything like ours you'll probably just cause another accident.

# Renault KWID

Price TBC, renault.com

# 3 WORLD

Become a virtual fly on the wall with this wideangle video camera. The 360Fly's special lens can see 360° around itself, meaning you don't actually need to point the camcorder at anything in particular, it simply films everything around it. When you play back video you can then pan around the footage to focus on whatever you want. It can be mounted virtually anywhere, making it perfect for extreme sports.

# 360Fly

Price TBC, 360fly.com

# 4 REAL SMART EARPHONES

Between Twitter-enabled kettles and internetconnected wigs there are some gadgets that don't really deserve the 'smart' moniker. The Dash, on the other hand, really is a pair of smart earphones. They function as a Bluetooth headset, a USB memory stick, fitness tracker, heart rate monitor and sports watch. They even let you channel some of the ambient noise through your mic, so you can hear what's going on around you.

### **Dash earphones** *Price TBC, Bragi.com*

# 5 BACK TO BACK SCREENS

Most current smartphones tend to last less than a full day once you start actually using them. In a bid to eke out energy, the YotaPhone 2 lets you transfer anything you'd view on the powerhungry front colour screen to the more frugal e-ink screen on the back. By doing so you can flick through emails, read a book or get updates from your favourite website without sapping your battery entirely.

# YotaPhone 2

Price TBC, Yotaphone.com

# 6 BLADE RUNNER

Adidas's latest running shoe will literally put a spring in your step. The idea is that the 'blades' dampen the force of your foot striking the ground, storing some of that kinetic energy in the bent plastic. As you lift your foot the springy blades straighten out, releasing that potential energy to propel you forwards. The effect is similar to that generated by the carbon fibre running blades that paralympian sprinters use.

Adidas Springblade £130, Adidas.co.uk



# SCOTTY

Could telepresence devices help us work anywhere? **Daniel Bennett** spends a week at home, to find out if he'll ever need to leave the house again...

IGHT NOW, AS I write this, I'm at the office in the Batman pyjamas I got for Christmas. Don't worry I haven't lost my mind (at least I don't think so). My presence is actually being virtually beamed to Focus HQ from my webcam to one of the machines pictured here. Since my camera can only see me from the waist up, I've decided to keep things casual. Besides, it hardly seems worth getting changed just to make the commute from bedroom to computer.

You might detect a note of smugness in those words, and you'd be right. Dodging the daily commute is something that most office workers dream of. Indeed, according to the Office of National Statistics, one in eight of us opt to work from home. But sending your presence remotely via a robot isn't just useful for dodging the rat race. Globalisation has meant that companies often keep a base of operations in each capital city and telepresence is therefore a real alternative to the ever-growing cost of travel.

But back to me and my pyjamas. Over the winter, during a waterlogged walk to work, I wondered whether I could do my job entirely from home. After all, there's very little I can't do with a computer in front of me. But could technology help me do it without losing any of the benefits of working as a team? I wanted to share ideas with colleagues, get involved in meetings and, most importantly, find out what everyone thought of last night's TV. So I've rolled in four Remote Presence Devices (RPDs) to find out if I really can have it all.

# **BEAM PRO**

\$16,000 (£9,628) www.suitabletech.com/beam

ACTUALLY BUYING A Beam Pro would set you back \$16,000.

Mercifully, rather than emptying out your life's savings, you can rent one – as we did – from a UK-based company like Pilot Presence (www.pilotpresence.com).

At 6ft (1.8m) tall, the Beam certainly has presence – easing it out its flight case took two of us. On first impressions, it looks like the kind of machine that might have made a good sidekick in an '80s movie. But behind the retro white computer paint, the Beam is solidly built. Its sure-footedness means you'll feel confident taking it anywhere – even a factory floor – without having to navigate every little bump in the road.

Setting it up just required us to plug in a keyboard and key in our Wi-Fi details. Despite some slightly intimidating menu screens, the Beam only took a few minutes to install and was no more complicated to configure than a wireless speaker.

Piloting the Beam is remarkably simple. Once you've registered your device and installed the software on your computer, the view from two cameras – one looking straight ahead, the other pointing at its base – is relayed back to your desktop. It stitches the two views together to give you a full body view of what's in front of you. On-screen, two parallel lines are laid over the images to show where your Beam is heading while you steer with the arrow keys.

Despite its considerable size, the Beam whizzed round the office faster than any other device we tested. There was absolutely zero delay between hitting forward on the keyboard at home and the device driving ahead. The head also houses some pretty sharp speakers, so I boomed out clearly and loudly to my colleagues, though occasionally a bit too loudly, as one co-worker pointed out. The microphone is remarkably sensitive

too: it picked up enough ambient noise – cars passing by, rain batting against the window – to make it feel like I was really in the office. It does, however, lack the ability to be able to adjust the height of the screen, which makes meetings where everyone is sat down a little awkward.



### **EYES FORWARD**

A camera with a light is aimed at the floor to help you avoid clipping people's ankles



### **SELF CHARGING**

Approach the dock, press the 'Park' button and the Beam Pro will reverse into place



### TAKE CONTROL

The Beam is controlled via desktop software that combines the views from both cameras





# DOUBLE

\$2,499 (£1,504) + \$299 (£180) for charging dock www.doublerobotics.com

BY COMPARISON THE Double is an altogether more sleek, modern and futuristic way to transmit vour presence into the office. In essence, it's an iPad strapped to a Segway. Setup involves installing the app on your tablet, connecting the device via Bluetooth to the Double, slotting it in upside down into the device's holder and then visiting a website on your browser to log in. Not needing to install any software is a bonus, since vou're then able to log in from any computer in the world, firewall permitting.

Once connected, little parking feet that hold the Double in place retract and gyroscopes and accelerometers keep the device perfectly balanced. This is a neat trick, which certainly wows onlookers, but ultimately it's also one of the Double's biggest flaws. It can't motor around the office at quite the same speed as the Beam and any bumps are a bit of a test. The small carpet strip in front of our kitchen sent the Double into a bit of a wobble, but after some back and forth it eventually stabilised without falling over. The rest of the time the Double glides around the office noiselessly, letting you sneak up to your colleagues (they really won't appreciate this).

The iPad's front-facing camera is your window into the world. and unfortunately it doesn't provide the sharpest image, particularly if you go anywhere with poor lighting. The iPad's audio sometimes wasn't loud enough either, with colleagues straining to hear me during meetings. A clever bit of engineering means that the rear-facing camera of the iPad looks at the base via a prism, but you can't see both views at once, meaning you have to stop and switch cameras to navigate around obstacles on the floor.

Once you've driven to your location you can switch the Beam

between sitting and standing height with its retractable neck, and even flick out your parking feet to conserve batteries. On your return you can slot the Double into a parking dock where it'll charge – though you will need to charge the iPad separately to make sure you don't get caught out.



### **PRISM PRECISION**

The iPad's rear-facing camera shows you the view below via a prism in the Double's 'head'



### **PUT YOUR FEET UP**

When you're not cruising around, extendable feet drop to hold the Double in place



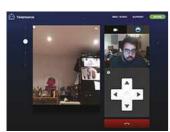
### MEET AND GREET

The Double is driven from your browser, but you can't see the view from both cameras at once

# BUDGET BOTS If you haven't got thousands to spend on a robotic alter-ego, here are two other ways of projecting yourself



ULTIMATELY THIS IS telepresence for kids. You simply slot your iPhone into the dock and open up the Romo app. From there the Romo has two modes. One turns your iPhone into a lovable blue alien robot and the other turns it



The Romo is controlled through your web browser and offers a child-friendly view

into a small telepresence device. The robot mode is a fantastic way to teach kids (big and small) about machine programming, but we'd borrowed it to test out telepresence abilities.

Of all the devices we tested, the Romo was by far the easiest to get working. Your app has a unique 'phone number' that you can dial from the Romo website. From there you can control the little robot via your keyboard. Of course, the cute little Romo was a little small for office life, but it was fantastically responsive and a real joy to use. In the end, it was more useful at home, zipping around my flat and pestering my other half while I was away at a conference.



The Romo's blue-faced alter-ego



A LOT OF my time on the devices was spent at my desk, chatting to my colleagues as usual, so the Kubi seemed like a viable option. To be more affordable it's done away with wheels and simply sits on a desk or a meeting room table, holding a tablet device (Android or iOS). Once you've downloaded the Kubi app and connected the two by Bluetooth, you can then remotely control the stand from a browser or another tablet or smartphone.

While you can't wheel around, you can turn to face different colleagues and pan up and down.



The Kubi is remotely controlled via this grid. Clicking on the screen will move it around

It's certainly a step up from plain old video conferencing, but it doesn't really feel like you have a true, mobile presence in the office.



Pan around a meeting room with the Kubi, but someone will have to carry you back to your desk

# VITAL STATS

How the telepresence devices stack up







	BEAM	DOUBLE	ROMO	KUBI
HEIGHT:	1.6m	1.2-1.5m	7.6cm (body only)	31cm (body only)
WEIGHT:	45kg	7kg WITHOUT IPAD	800g	3kg
SCREEN:	17-INCH LCD	9-INCH IPAD	4-INCH IPHONE	DEPENDS ON TABLET USED
SPEED:	0.7M/S	0.4M/S	0.3M/S	N/A
PRICE:	\$16,000 (£9,628)	\$2,499 (£1,504) + \$299	\$149 (£90)	\$499 (£300)

# THE WINNER: **BEAM PRO**

THE BEST SUBSTITUTE for my presence in the office was the Beam. It was simple to use, reliable and quick. Back at home it sent back the best audio and video from the office and at work it felt more dynamic and stable. But there's a simple reason for this: it's nearly six times the price.

The Double is cheaper. It's by no means a budget device, but it's

an affordable way to bring telepresence to an office. It's more innovative than the Beam Pro and there's little doubt in my mind that the Double represents what RPDs will look like in the future, with its clever use of gyroscopes to stay upright. It's thin, relatively light and makes no noise at all. But for now, its reliance on the iPad remains a bit

of a weakness. The tablet's speaker is a little on the quiet side and the picture from the front-facing camera is a little grainy, particularly in low light.

The pair of desktop devices, the Romo and Kubi, meanwhile are innovative, relatively low-cost devices that provide a convenient way to see if telepresence will work for you.



# FINAL VERDICT Can you avoid the office altogether?

PROBABLY NOT, OF course I had to come back to work at some point. While I was happy pootling about in my robot body, no device can permanently replace your presence at work. For a start, the beginning of every conversation required a 10-minute chat just to explain why I was a floating head on a screen. Volume was also an issue. At times the whole office could hear conversations meant for the person sat next to me; that was until I turned down the volume.

I was also trapped on my floor. Stairs were my Kryptonite and elevators killed the Wi-Fi connection, so an escort was needed to take the devices to another department. While the camera on the Beam was the sharper of the two and had a digital zoom, neither would pick out fine details. The poor video quality may have been due to the internet bandwidth, but it was tricky to see images being pointed out on my colleagues' computers.

Then there was the interaction. If you've ever made a video call



on Skype, you'll know how tricky having a natural conversation can be. With my face beamed to a screen, there's none of the body language present that people subconsciously read when they're talking. This results

in stilted chats that were tricky to navigate. When I stopped talking, colleagues had to wait to see if I'd finished the sentence. Despite this, telepresence technology has come a long way and can only get better.

# THE GEOLOGY OF THE BRITISHES

# **BY CHERRY LEWIS**

By classifying the wide variety of rocks that make up our island, an undertaking that took centuries to achieve, we've been able to tell the rich story of Britain's geological past

OMO ERECTUS FIRST
arrived in Britain around
three quarters of a million
years ago, bringing with them
the ability to fashion crude
flint tools, which were used
in the butchering of animals.
It was a time when Britain
was still attached to Europe,
by a landmass that eventually
became submerged with rising sea
levels at the end of the last ice age.

Over the following millennia, we *Homo sapiens* roamed the land looking for flints with which to make increasingly sophisticated tools. We also sought metals for weaponry, gold for decoration and stones for building religious sites like Stonehenge. Coal was important too, not just for smelting ores but for burning limestone to fertilise the land in order to secure a reliable supply of food.

During our search for these resources we accumulated an indigenous knowledge about where such assets might be found and the rock types in which they were located. Chalk, limestone, granite, sandstone, clay and many other rock types were probably recognised from very early times. But it was not until we really

understood fossils that we could put this knowledge to best use.

In 1027, the Persian philosopher Avenica first outlined the foundational principle of geology. It stated that sedimentary layers are deposited in sequence, with the oldest on the bottom and the youngest on top. This 'law of superposition' was fully formulated in 1669 by the Danish scientist Nicolas Steno, who reasoned that strata were formed when particles suspended in water fell to the bottom, creating horizontal layers. Any deviation from the horizontal was due to a later disturbance. While Steno



Black Church Rock in Devon exposes different layers of rock that have subsequently been tilted over time

was not the only naturalist of his day to propose that fossils had once been living creatures, he argued for the first time that fossils were snapshots of life at different moments in Earth's history. Over the following centuries there were many opposing theories, but once these two principles had been established, the stage was set for a greater understanding of what fossils could tell us.

# **SUBTERRANEAN SCIENCE**

During the Industrial Revolution, Britain needed large amounts of coal and raw materials to be transported around the country. That led, in the mid 1700s, to a period of extensive canal-building. In 1794, the surveyor William Smith was supervising construction of the Somerset Coal Canal. Excavations started in July 1795 in a west-to-east direction along two parallel valleys, about 3km (1.8 miles) apart. As the excavations proceeded, they revealed the gently dipping strata one by one, allowing Smith to compare the layers in one branch of the canal with those in the other. This allowed him to work out the order in which the strata had been laid

# How do we know?



down. Furthermore, he noticed that each layer had a characteristic suite of fossils which "always succeed one another in the same order". It was therefore possible to match two strata containing the same suite of fossils, even though they were miles apart.

Using this method of correlating fossils, Smith was able to detail the 23 strata that lay between the Chalk (Cretaceous) and the Coal Measures (Carboniferous) in the area around Bath. This proved to be an advance of enormous magnitude, since his stratigraphic column provided a standard against which rocks anywhere

in the country could be compared. Strata that had previously been given different names could be identified as being one and the same. When Smith realised he could make maps to display the strata by giving them different colours, he produced the first-ever large-scale geological map in 1799. He followed this map of Bath with the first geological map of Britain in 1815.

Smith's ideas spread quickly. By 1812, even before Smith had published his map of Britain, the metallurgist David Mushet had created a geological cross-section of the Forest of Dean coal basin. Mushet had come to the Forest of Dean in search of iron and coal, and his work correlated the different coal seams. He used data taken from strata revealed in boreholes across the region – boreholes drilled in the search for coal and iron. This early use of borehole data meant Mushet could also correlate rocks overlying coal seams in the Forest of Dean with those overlying coals in the Welsh, Bristol and Somerset coal basins. This enabled him to predict where coal might be found elsewhere.

Despite these advances, geology was still an infant science. At that time, the word 'fossil' meant anything that had been dug out of the Earth and included minerals and archaeological

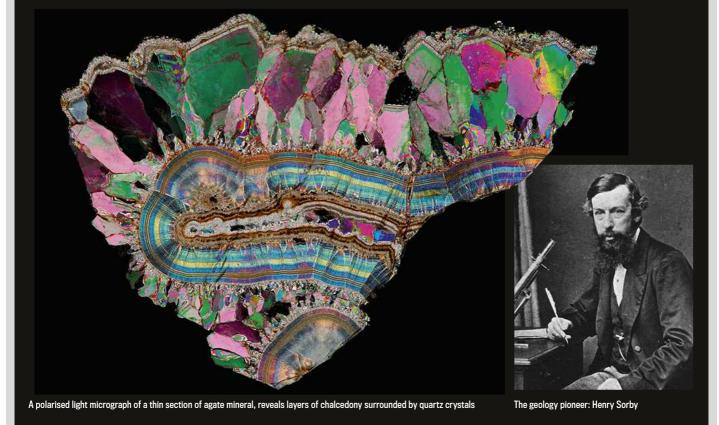
# THE KEY EXPERIMENT

By slicing rock into extremely thin sections and studying them with a polarising microscope, Henry Sorby revolutionised the science of geology

HENRY SORBY'S APPLICATION of the polarising microscope to examine rocks resulted from a chance meeting on a train with a Manchester surgeon who taught him to make sections of fossil wood, teeth and bones. It occurred to Sorby that a great deal might be learned by applying a similar method to the study of rocks. He made numerous thin sections by first grinding a slice of rock roughly, smoothing it on a lead

plate with coarse emery, and finishing on a copper plate with fine emery. The thickness of 30 microns (millionths of a metre) that he achieved is still the standard used today, over 160 years later.

In 1851, Sorby published a paper describing this technique and the mineral content of a thin section of sandstone. Using a microscope fitted with polarised light, he determined that some of the particles were calcite, some were quartz and others agate, which would have been impossible using the old method of crushing rocks. Unfortunately, this new technique of examining rocks did not find favour among most geologists of the day and was ridiculed by many. It wasn't until the 1860s that the technique of using polarised light to identify minerals became established as an essential tool for the examination of rocks.



artefacts as well as organic fossils. The word 'palaeontology' wasn't coined until 1822 and the word 'scientist' was first published as late as 1834. It's telling that in 1804, when writing one of the first books on fossils published in English, James Parkinson (who also identified Parkinson's disease), complained about the difficulty of writing about a science with no name.

# **SOCIETY SUCCESS**

Nevertheless, interest in geology was growing rapidly, due largely to the demand for coal, iron and other metals. In 1807 this led to the establishment of the world's first Geological Society in London. One objective was to identify where Britain's wealth lay underground and another was to sort out the geological nomenclature.

In every part of the country, the same rocks had different names, making it extremely difficult to know if two rocks were identical if they did not contain fossils; fossils are in fact found in only 15 per cent of rocks. To this end the Society's first President, George Greenough, invited people to send in geological information from their local areas. Over the next decade, maps, rocks and details about geology flooded in from all over the country. Such was the Society's success it had to move premises three times to accommodate all the material!

Progress during geology's golden age, the 1830s, was swift. By the 1840s all the geological periods from the Tertiary to the Cambrian had been identified and named, except for the Ordovician. A 'period' is a subdivision of geological time that enables crossreferencing of rocks and geological events from place to place. Periods are grouped into eras, and eras into eons. The younger periods posed few problems because they mostly contained large numbers of fossils, which enabled their chronology to be ordered quite easily. The older periods were more controversial, however. They contained fewer fossils so were harder to position accurately relative to each other. In addition, older rocks have often been deformed and overturned, making it more difficult to understand the original sequence.

In 1832, Henry Thomas De la Beche undertook a geological survey of Devon. This work eventually led to the establishment of the Geological Survey in 1835, but not before De

# **CAST OF**The men who established an expectation of the compact of

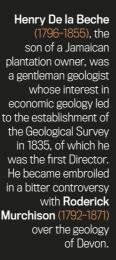




Nicolas Steno (1638-1686) was born into a wealthy Lutheran family in Denmark. His study of geological processes culminated with his great work, *Prodromus*, now regarded as a masterpiece. Unfortunately, his conversion to Catholicism produced an intellectual conflict with his geological observations, and shortly after writing Prodromus, Steno lost interest in geology.



George Greenough (1778-1855), whose independent means facilitated his interest in rocks, was important in the development of British geology due to his organisational skills. In 1807 he became the first President of the Geological Society and can largely be credited for its rapid success.







Henry Sorby (1826-1908) was born near Sheffield. His early training in chemistry and mathematics influenced his approach to research. He made several observations of significance to geology and developed the technique of making thin sections of rocks and observing the minerals they contained under a polarising microscope. This transformed the classification of rocks.

la Beche had suffered great public embarrassment. While he mapped the strata in Devon, his colleagues Roderick Murchison and Adam Sedgwick were similarly engaged in Wales, respectively establishing the Silurian and Cambrian systems. Everyone assumed that the rocks in Devon were around the same age as those in Wales. But in 1834, when De la Beche found Carboniferous fossils in coals embedded in the middle of rocks he thought were Silurian, he declared that William Smith's theory of ordering the rocks using the fossils they contained must be wrong. Murchison leapt to the attack even though he had never examined the Devonshire strata himself. This deeply offended De la Beche, who believed that the validity of field work should not be questioned on theoretical grounds.

When Murchison and Sedgwick examined the Devonshire rocks themselves in 1836, they found that De la Beche had made a mapping error. The coal deposits were in fact at the top of the Devonshire strata rather than in the middle, so they assumed the coal must lie at the bottom of the Carboniferous, sitting on the older Silurian rocks - what's known as an unconformity (see 'Need to know', right). De la Beche was publicly criticised and the fledgling Geological Survey was nearly brought to an untimely end. But the arguments didn't end there. De la Beche was forced to admit his error, but he insisted that there was no unconformity between the coal strata and the older Silurian rocks. To their discomfort, Murchison and Sedgwick could not identify an unconformity either and had to admit that there wasn't one.

## THE DEVON CONUNDRUM

There followed much debate and extensive investigations ranging as far afield as Russia, where in 1840 Murchison discovered a layer similar to the coal found in Devon, positioned between well-defined Silurian and Carboniferous deposits. This finally put an end to what became known as the Great Devonian Controversy and led to the definition of a new period called the Devonian. It also led to a fundamental change in geological practice and the value of fossils as stratigraphic indicators was established beyond question. Fortunately, the Geological Survey

# **NEED TO KNOW**

You'll need these key terms to understand the history of geology

# **IGNEOUS ROCKS**

 ☐ These form when molten rock cools and solidifies, either on the Earth's surface, like basalt, or within the crust like granite.

# METAMORPHIC ROCKS

A Pre-existing rocks that have been transformed by intense heat and pressure.

# > POLARISED LIGHT

This is where light that is normally scattered in all directions is restricted so that you can only see the waves that are vibrating in one direction.

............

•••••

# 4 POLARISING LIGHT MICROSCOPY

An technique that uses filters to configure the movement of polarised light waves, forcing their vibration in one direction.

# SEDIMENTARY ROCKS

These form from the deposition, usually in water, of eroded material from other rocks.

••••••

# **CUNCONFORMITY**

O This is a gap between two rock layers that represents a break in the geologic record, often of hundreds of millions of years.

survived this early trauma and De la Beche became its first Director. Both the Geological Society and the Geological Survey still exist today.

By the late 19th Century, geologists recognised that rocks were made up of individual minerals, and it was the size and composition of these minerals that determined the type of rock. There were three basic types – igneous, sedimentary and metamorphic - but as geological mapping became more refined, a more precise classification was required. It became necessary to identify which minerals were present and in what quantities. However, while it was possible to see minerals with the naked eye in rocks such as granite, other rocks such as basalts were harder to classify, because



Sedimentary rock at Sandymouth Bay in Cornwall shows distinct bands that enable geologists to identify the time period that the strata was formed

the minerals they contain are extremely small.

Until the 1860s, geologists would crush up rocks to a coarse powder and examine them under the microscope, but identifying minerals this way was rather crude, and it was very difficult to accurately measure the proportions. It was not until polarised light was applied to the study of minerals under the microscope that a systematic identification of rocks became possible (see 'The key experiment', p92).

The first steps were taken by Henry Sorby, who prepared thin sections of minerals and fossil woods for microscopic investigation. A thin section, as the name suggests, is a polished slice of rock so thin that you can see through it. When placed between pieces of glass on a polarising microscope, each mineral in the rock slice displays different optical properties - mainly colour and shape - that can be used to identify it very accurately. This finally established a scientific method for classifying rocks and was to transform our ability to distinguish one rock from another.

The geology of the British Isles is renowned for its diversity. Rocks of almost all geological ages can be found and mapping them over the past two centuries was the single most important contribution to our understanding of our islands' geology. Then in the 1960s, development of the theory of plate tectonics began to unravel Britain's complex tectonic history. Over the past four billion years or so, as Britain wandered the globe, it accumulated a record of warm and cold seas, deserts, tropical swamps, giant rivers, glaciations, earthquakes, volcanic eruptions, continental collisions, and the evolution of life as preserved in its fossils. Our knowledge of that record has slowly accumulated, but even today we still don't comprehend it all.

Dr Cherry Lewis is a geologist and the author of The Dating Game: One Man's Search For The Age Of The Earth

### Find out more

RADIO 192-95 frea 198 w

Listen to 'Early Geology', an episode of *In Our Time* in which Melvyn Bragg

discusses how the science of studying rocks emerged. http://bbc.in/KUAZfP

# Only Mammoth mattresses are clinically proven to give you a better night's sleep

So with 25% OFF all Mammoth mattresses in our Easter Sale why choose anything else?

According to The Sleep Council, the lifespan of a standard mattress is 20,000 hours of use - that's 7 years for the average person. Beyond this, beds can leave you sleeping in the wrong position, resulting in pain and discomfort. Whether it's a creaked neck or a sore back, missing out on sleep night after night can have long-term implications for your health and wellbeing. And with an estimated 50% of people suffering from sleep problems in the UK today, it is even more important that we make the right choice when it comes to change.

If your mattress is getting a bit long in the tooth, why not use our Easter Sale as the perfect excuse to freshen things up in the bedroom.



An estimated

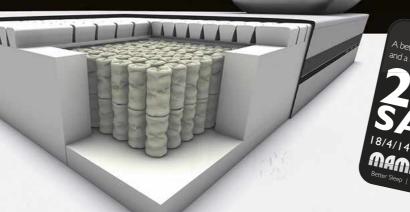
of people in the

UK suffer from sleep problems

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# TO DO LIST

WATCH







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# PLAN YOUR MONTH AHEAD WITH OUR EXPERT GUIDE

# PICK OF THE MONTH



"I REMEMBER AS a kid being in a plane, looking down on the clouds and thinking, what would it be like to walk about on them?"
When we flew the airship into a cloud, it was a childhood ambition fulfilled."

Meteorologist Felicity Aston was one of the team sent aloft by the BBC to study the private life of clouds. Their unusual choice of aircraft let them manoeuvre in and out of clouds instead of speeding through them as commercial aeroplanes do. Though, as airships are not designed to fly as high as airliners, that did give them some problems crossing the Rocky Mountains. "A lot of the scientific equipment went out," says Felicity. "And we had to chuck out most of the film crew." Not in mid-air, thankfully.

During their month-long expedition from coast to coast across the USA, the team used their flying laboratory to study the atmosphere and the things that live in it: everything from bats to bacteria. Entomologist Dr Sarah Beynon and daredevil Andy Torbet joined Aston, who spent years as a meteorologist in the Antarctic. They used lasers to look for high-altitude clouds in the stratosphere

and measured the energy stored in a cumulus cloud – energy that would be released in rain or in destructive storms.

They even weighed a cloud. Felicity is coy about how much an apparently weightless confection of white would tip the scales, but says it's 'over a tonne'. And if you're wondering how they carried a month's worth of supplies – they didn't. Every night the airship landed using a low-tech method involving hefty men and some ropes. "There wasn't enough room for everyone to sleep on board," says Felicity with audible regret. "And the pilot needed a break." She confesses to feeling a real pang when, at the end of the adventure, they all stood on the Californian coast to wave their aerial home off into the sunset.

TIMANDRA HARKNESS



Cloud Lab airs this May on BBC Two - check radiotimes.com for details

# **DON'T MISS!**



# **Treasure Hunters**

Dallas Campbell and Ellie Harrison travel the globe to uncover the world's most precious gems. p98



# Imagining The Future Of Medicine

Dara Ó Briain and guests discuss all things health at the Royal Albert Hall. p101



# The Man Who Couldn't Stop

Find out what it's like to live with obsessive compulsive disorder. p102

FROM **20** MARCH

# **Big History**

H2, 20 March, 5pm, then Fridays, 9pm



HOW DID SALT shape the human story? This series takes a new approach to history, exploring how fundamental ideas link the deepest principles of science to the reality of human societies. Narrated by Bryan Cranston, it brings in academics and other experts to flesh out ambitious storytelling. One episode is about gravity, but don't let it get you down.

ROM **6** APRIL

# **Dangerous Flights**

Discovery, 9pm



THE SERIES FOLLOWING aircraft delivery teams returns for a second season. Braving blizzards, flying over wild territory and Arctic oceans, the crews have responsibility for multimillion-dollar aircraft – and for each others' lives. A gripping reminder that safe air travel depends on gallons of behind-the-scenes courage and determination.

FROM **Q** APRII

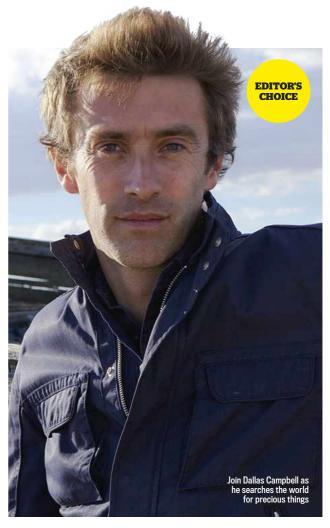
# Science Of Stupid

National Geographic, 10pm



A BOMBPROOF EXCUSE to re-watch internet videos of epic fails. But it's not voyeuristic sadism if Richard Hammond explains the science behind it, right? So relax and feel superior to people launching fireworks from bodily orifices and backflipping off roofs. Includes slow motion where that would be funnier... er, we mean more educational.

TIMANDRA HARKNESS is a stand-up comedian and a presenter on BBC Worldwide's YouTube channel Head Squeeze



ADRII

# **The Treasure Hunters**

BBC One. April TBC

LIKE THE PIRATES of legend, Ellie Harrison and Dallas Campbell sail the seven seas in search of precious objects.

Diamonds may be a girl's best friend, according to the song, but to retrieve them from the ocean floor takes a hefty machine. And digging for gold takes the pair down one of the world's deepest mines. Today's treasure is found by engineers with advanced technology, not by swashbucklers armed with a map and a cutlass.

Episode two sees Dallas and Ellie turn their attention

to treasures created by the human hand. Gemstones sparkle only because they are cut and polished by experts, each facet designed to reflect and refract the light – a single slip of the hand can cost millions of pounds.

Then it's back to looking for lost, sunken and buried hoards, diving to shipwrecks and searching for treasure chests, with the hunters travelling from China to Egypt to find them.

Ancient mysteries and spectacular locations should make for absorbing television.

13 APRI

# The Sky At Night

BBC Four, 10pm



PRESENTERS CHRIS LINTOTT and Maggie Aderin-Pocock celebrate 10 years of robotic presence on Mars. NASA's Curiosity is only the latest explorer to trundle around the Red Planet, zapping rocks and sending back bleakly beautiful holiday snaps. This special looks at what we've learned by sending our mechanical friends to look around on our behalf.

17 APRII

# Time Bomb Iceland

Discovery Science, 9pm



Eyjafjallajokull Fimmvordhaus volcano, Iceland

WITHOUT VOLCANOES, Iceland probably wouldn't exist. The island of Surtsey, its most recent addition, appeared in a series of eruptions in the 1960s. This documentary meets Nordic Volcanological Center experts, Italian scientists and emergency planners to find out where Iceland might erupt next, and what to worry about when it does.

27 APRIL

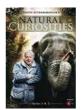
# **Stephen Hawking's Science Of The Future**

National Geographic, 8pm



AUTONOMOUS HELICOPTERS? ROBOTS whose sense of touch matches yours? We all have visions of future technology, and here Professor Stephen Hawking enlists five top scientists to explore his. They identify the innovations of today that could transform our lives tomorrow, from transport to artificial intelligence. Find out how our cities could be powered by your daily commute, how medicine will help newborn babies, and which technologies will help you to live longer.

# **DVD & BLU-RAY**



# David Attenborough's Natural Curiosities: Series 1 and 2

2Entertain, £15.69, DVD

SIR DAVID DISCOVERS what pairs of creatures, linked by an evolutionary quirk, have in common.



# **Ice Pilots**

Delta Home Entertainment, £14.40, DVD

BUFFALO AIRWAYS, BASED in Canada, flies classic planes through blizzards, across the Atlantic and in -30°C conditions. This series follows recruits eager to fly aircraft as old as their parents.

# ONLINE

OXFORD MART

# Oxford Martin School seminars

www.oxfordmartin.ox.ac.uk/media



JOIN UNIVERSITY OF Oxford seminars live, or watch later. Past events include artificial intelligence, biodiversity and citizen science, by speakers including physicist David Deutsch and Baroness Helena Kennedy (pictured).

YOUTUBE

# Headsqueeze: What Is The Higgs Boson?

http://youtu.be/svhEfpaFWKg



PARTICLE PHYSICIST Tom Whyntie and cosmologist Andrew Pontzen tackle the question that we're all too shy to ask but probably really should. Although they may not agree on the answer...

BBC IPLAYER

# Bang Goes The Theory - Energy

bbc.in/1gfHZGC



JEM STANSFIELD, LIZ Bonnin and Maggie Philbin start series 8 by asking how Britain will keep the lights on in 2034. Will renewables be the future of energy, or will we be relying on 'liquid air'? Available till 5 May.

WITH TIMANDRA HARKNESS

2 APRIL

# It Is Rocket Science!

BBC Radio 4, 11pm

The factually accurate, space-obsessed comedy of Helen Keen, with Susv Kane and Peter Serafinowicz, is back for a welcome third series. The four new episodes will include Harvard's human computers, UFOs of the Wild West and what Isaac Newton liked to do in his time off.

## 19 APRIL

# **Atlantic Crossing**

BBC Radio 4, 19 April, 8pm

"HEATHROW TOWER. THIS is Speedbird One..." is the kind of thing you'd expect from cockpit chatter. But these days the sound of radio communications between pilots and Air Traffic Control is being superseded by text messaging. Christine Finn takes a transatlantic journey in sound, eavesdropping on pilots, control towers, and those who listen in.



Are texts replacing cockpit radio?

## **26** APRIL

# The Forum: Plasticity

BBC World Service, various times

THIS EDITION OF the regular panel-based programme, hosted by Bridget Kendall, looks at the plasticity of the brain. Takao Hensch of Harvard is one of the guests discussing how our brains adapt and compensate so that we can keep sensing, moving and thinking.



How adaptable is the brain?

### 29 APRIL

# **Born Smart**

BBC Radio 4, time tbc

SOCIAL MOBILITY, EDUCATION and parenting are hot topics right now, and all are full of controversy. They're about to get a lot more controversial, as geneticist and author Adam Rutherford takes a deep breath and devotes a three-part series to examining the elephant in the classroom intelligence and genetics.

# ONLINE: BBC

# Elements

www.bbc.co.uk/podcasts/series/elements

THIS BBC WORLD Service series looks at the global economy through the building blocks of the physical world. For example, how did tin revolutionise glassmaking, and how does helium fight cancer? Each episode follows one element of the periodic table.





# **TOUCH** SMARTPHONE & TABLET APPS

WITH CHRISTOPHER BRENNAN

# **Weather Clock**

Android 4.0.3 or later, Mobile Rise, free (60p in-app purchase to remove ads)



THE WEATHER IS a topic of heated debate in many countries, and especially so in the UK. It should come as no surprise, then, that there are plenty of apps related to the subject. Weather Clock has a nice twist, in that you can see what will be happening at certain points during the day at a glance. Yes, it's nice and sunny first thing, but will it be raining by lunch? The clean design gives you a simple way to instantly see a day-long forecast. Longer-range predictions are also available.

# Brian Cox's Wonders Of Life

iPad, iPhone, iPod touch, iOS 7 or later, HarperCollins, £3.99



THE WONDERS OF Life app is an accompaniment to the Prof Brian Cox TV series of the same name. The app itself is well designed and the high-quality imagery really adds to the overall look and feel. As you might expect, the information included is accessible and yet still thoroughly informative. Each of the sections is filled with images and video, which Brian himself narrates. As well as larger animals like kangaroos, there's detailed information about microscopic organisms and DNA, all of which helps you discover the natural world.

# Science Today

iPad, iPhone, iPod touch, iOS 6 or later, California Academy of Sciences, free



THE SCIENCE TODAY app from the California Academy of Sciences brings together some of the most cutting-edge research and presents it in a really easy-to-digest format. Covering topics such as space, Earth and the natural world, the range of news will keep you entertained for hours. One of the highlights of this app is the quality of the pictures, with some stunning photography used to illustrate the stories. It also includes interviews with staff from the Academy so you can hear from the people working at the scientific coalface.

CHRISTOPHER BRENNAN is a technology journalist and app expert



FROM **28** MARCH

# Power Of Ten: Inventing Logarithms

National Museum of Scotland, Edinburgh, until 6 July, free, www.nms.ac.uk



Scotsman John Napier revolutionised maths in the 17th Century with the invention of the logarithm. Discover his work at this exhibition.

9 APRII

# **Unlocking James Lovelock**

Science Museum, London, free, www.sciencemuseum.org.uk

James Lovelock is one of Britain's greatest living scientists. Delve into the archives of the maverick thinker at this event.

23 APRIL

# As If By Magic!

Royal Institution, London, 6pm, £12/£8, free to members, www.rigb.org

You won't see David Blaine, but you can explore magical molecules, where liquids boil at room temperature and gases are heavier than air.

25 APRIL

# The Science Of Laughter

Royal Institution, London, 8-9.15pm, £17, free to members, www.rigb.org

Why do we laugh? It's all down to social bonding. Find out about laughter in other animals and the acoustics of our giggles.

28 APRIL

# Science Cafe: People In Pain

Tobacco Factory, Bristol, 8-10pm, free http://bscia-bsba.org.uk



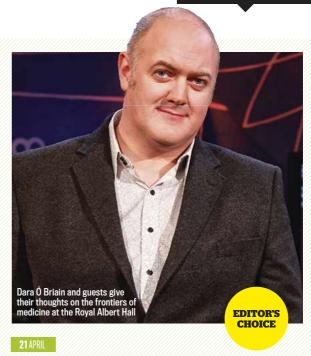
How do you measure the success of pain treatments? At this talk, physiotherapist Dr Pete Gladwell details his fascinating work that reveals simple distraction could be a good source of pain relief.

13 MAY

# Cosmic Fire On Earth

Burlington House, London, 1pm, free, www.ras.org.uk

Travel deep into the heart of stars at this talk to learn about the forces at work, and how to use their cosmic power to ensure our survival.



# **Imagining The Future Of Medicine**

Royal Albert Hall, London, 2pm, £7.60-£33.10, royalalberthall.com

DARA Ó BRIAIN and pals have peered into a crystal ball to reveal their vision of where medicine is heading. At this afternoon of talks, TEDMED Curator Jay Walker leads the way. Big names include: *Bad Science* writer Ben Goldacre, eminent medical engineer Prof Chris Toumazou discussing devices for medical diagnosis, Prof Sarah-Jayne Blakemore on how the social brain develops in teenagers and Mark Wilson on his work as a doctor on Everest expeditions.

FROM 16 MAY

# Fat Lab

Science Gallery, Dublin, until 29 June, free, dublin.sciencegallery.com

Global obesity has doubled since 1980 and at least 2.8 million deaths a year are caused by the condition. This exhibition looks at causes and treatments, and even lets you take part in experiments.

FROM **17** MAY

# **Body Worlds Vital**

Life, Newcastle, until 2 November, from £12, life.org.uk



World-renowned anatomist Gunther von Hagens brings his exhibition of real human bodies to Newcastle. It's the ultimate way to learn about anatomy, physiology and health. Not for the faint hearted!

UNTIL **26** MAY

# **Beautiful Science**

British Library, London, free, www.bl.uk



From John Snow's plotting of the 1854 London cholera outbreak to depictions of the tree of life, find out how data can become art.

JHENI OSMAN is a science writer and the author of 100 Ideas That Changed The World (BBC Books, £9.99)



🕕 Hardback 🕑 Paperback

# The Man Who Couldn't Stop

OCD, And The True Story Of A Life Lost In Thought

**David Adam** 

Picador 4 £16.99

ARLY ON IN this book David Adam claims that most of us have around 4,000 thoughts a day. These mind wanderings are, for the most part, inconsequential: thoughts of what to have for lunch, what to buy, what to do at the weekend. Others are more intrusive. 'Do I look fat?' 'I'm never going to pass that exam.' People don't like me.' These hard-to-shake intrusions are the bread and butter of the whirlwind of negativity that captivates the depressive mind.

But, as illustrated beautifully in this book, nothing tops the insidious and vicious inventiveness of the mind taken over by obsessive-compulsive disorder: OCD. This is the human mind in all its complexity turning in on itself and wreaking havoc, surreptitiously convincing its prey that its obsession is bound to happen.

In David Adam's case, the obsession was his conviction that he would catch AIDS. He knew it was irrational, he knew it was highly unlikely – but there's the rub: 'highly unlikely' not 'impossible'. That was the crack through which OCD could squeeze. And so began – in 1991 – an escalating obsession that led to a multitude of compulsions in an equally irrational attempt to quell the disturbing

"In David
Adam's case,
the obsession
was his conviction
that he would
catch AIDS"

THE MAN WHO COULDN'T STOP
MAN WHO COULDN'T STOP
MAN WHO COULDN'T STOP
THE MAN WHO COULDN'T STOP

DAVID ADAM

and intrusive thoughts that stormed through his head.

LIFE LOST IN THOUGHT

Since his obsession began, he tells us, life went on autopilot. While he was 'up-front and central', his mind was now elsewhere. 'I looked the part and smiled at the passengers, but something else was flying the plane.' The Man Who Couldn't Stop is a captivating first-person account of how a blizzard of unwanted thoughts can become a personal nightmare. At times shocking, at times tragic, at times unbelievably funny, it is a wonderful read.

A science writer, Adam has an eye for a good study, bringing even the driest of experiments to life. He takes us on a journey through the history of OCD, providing an up-to-date and accurate account of the current scientific understanding of this devastating condition. As a psychologist, I am familiar with much of the science he discusses. But he describes studies, old and new, in a fresh way, invigorating them with personal tales and haunting anecdotes.

This book will appeal to all those who are fascinated by the human mind and its unending ability to delight and to torment.

ELAINE FOX is Professor of Cognitive & Affective Psychology at Oxford University and the author of *Rainy Brain Sunny Brain* 

# **MEET THE AUTHOR**



# David Adam

# How did your OCD start?

My OCD is on a very specific thought of HIV and AIDS. I was a child of the '80s, when there was a great deal of information about how dangerous AIDS was. It started with these alien thoughts about whether I could have caught AIDS from a girl I hadn't had sex with. It sounds silly and yet, when that thought doesn't go away, you start to take it more seriously and you start checking and asking people as a way to make it disappear.

# Have scientists pinpointed a part of the brain that's linked to OCD?

Yes, but in quite vague terms. They've found a part of the brain that seems to show abnormal activity in people with OCD: a very old, deep part called the basal ganglia. This region holds the programs for very rapid, almost instinctual responses and there's a theory that something could go wrong here – that it hyperstimulates or that you can't control it well enough. There's also some evidence that ritualistic behaviour in animals such as dogs and mice is linked to the basal ganglia.

### Is there any treatment for OCD?

It's only really since the '80s that we've developed an understanding of how it can be treated. We're now at the point where there are two basic treatments. One is drugs, and the other is what's called 'cognitive behavioural therapy'. This can involve stimulating the sufferer's anxiety in a safe environment. The idea is that once the person recognises that the anxiety will go away by itself, they won't feel the need to perform the ritual.

# **MORE ON THE PODCAST**

Listen to the full interview with David Adam at sciencefocus.com/podcasts



# The Perfect Theory

A Century Of Geniuses And The Battle Over General Relativity

Pedro G Ferreira

Little, Brown 🖽 £20

SCIENTIFIC RESEARCH IS sometimes mind-bendingly hard and tedious. Yet it's also often rocked by heated controversies, rivalry and outright feuding. As a professor of astrophysics at Oxford University, Pedro Ferreira works on issues seemingly well-insulated from such human foibles. He's an expert on Einstein's theory of gravity. General Relativity. But as he shows in this entertaining account, Einstein's 'perfect theory' has been the source of many bitter disputes - and still is.

Within weeks of its emergence in 1915, General Relativity had provoked a spat between Einstein and the greatest mathematician of the day. David Hilbert. who had independently discovered the same equations. Only their mutual respect prevented a bitter dispute over priority.

In the years that followed, other scientists showed no such restraint, with brilliant if immodest theorists telling everyone they were stupid, only to see their own ideas crumble, to the obvious pleasure of others. Prof Ferreira is an outstanding storyteller, and the tales here reveal more about how science really works than any number of textbooks.

ROBERT MATTHEWS is a visiting reader in science at Aston University



# The Knowledge

How To Rebuild Our World From Scratch

Lewis Dartnell

The Bodley Head # £20

'THE WORLD AS we know it has ended.' A bleak start to Lewis Dartnell's thought experiment, but one that gives him enormous freedom to explore why we need science and technology.

Starting with the basics - food, shelter, drinking water - rapidly forces us to take in some basic physics and chemistry, along with engineering, key bits of history, and observations on the technology used in developing countries.

There is no shortage of quotable pub facts. Did you know, for example, that the word alkali comes from the Arabic, al-Qaliy, meaning 'burnt ashes'? Because you'll be burning wood, or seaweed, to get the raw materials for soap or iodine.

The conceit is that this book tells you everything you'll need to reboot civilization, from agriculture to zinc batteries. It's a lot of ground to cover, making for a satisfyingly dense read, all conveyed with no expectation of prior scientific knowledge. At times, the quantity of technical know-how would benefit from more diagrams and illustrations. Mostly, though. Dartnell has a light turn of phrase and a gift for analogy that makes the body of knowledge easy to absorb. 

TIMANDRA HARKNESS is a presenter of BBC Worldwide's YouTube channel Head Squeeze



# The World's Great Wonders

How They Were Made & Why They Are Amazing

Jheni Osman

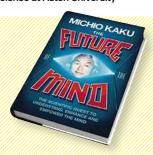
Lonely Planet 1 £19.99

WHAT MAKES A wonder of the world? For the Ancient Greek historian Herodotus, they were seven man-made marvels ranging from the Pyramids to the Colossus of Rhodes. Later writers expanded the list, including cultures far beyond those known to the classical Greeks, the achievements of modern architecture, and the most awesome sights the natural world has to offer.

Jheni Osman's new book follows in this long tradition, offering an enticing and informative overview of 50 wonders both natural and artificial. They range from old favourites such as the Grand Canvon and the Great Pyramid of Giza, to 21st Century achievements such as the Burj Khalifa and the Large Hadron Collider.

Despite being at heart a beautifully presented reference book, The World's Great Wonders reveals its 'Lonely Planet' heritage through useful practical information supporting each entry. The vast majority are also adorned with stunning, specially commissioned maps. Osman's text is clear and engaging throughout, making the whole book an irresistible package for any armchair traveller. Time to start a checklist. I think!

GILES SPARROW is a science writer and the author of Physics In Minutes



# The Future Of The Mind

The Scientific Quest To Understand. **Enhance And Empower The Mind** 

Michio Kaku

Allen Lane # £20

THERE'S AN XKCD comic where a physicist annoys people in other disciplines by stating that their field can be reduced to a simple model with a few variables to account for complexity. Michio Kaku's The Future Of The Mind is essentially 350 pages of that.

Kaku clarifies that the mind has eluded definition for centuries, then defines it using physics. Kaku paints a picture of neuroscience and related fields as scrabbling around with their primitive tools before the advanced tech of physics benevolently stepped in. MRIs directly read thoughts (they don't), and anything can be controlled with a chip in the brain (it really can't).

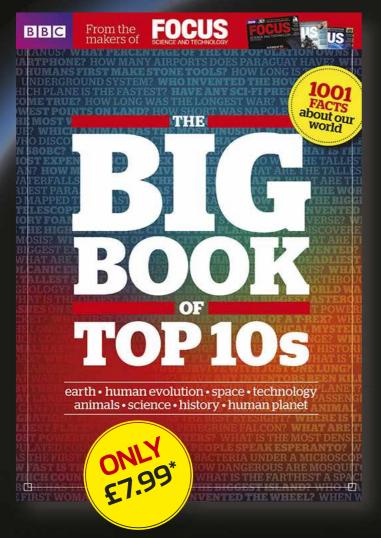
He's clearly interested and fascinated by the mind and writes well, but his physics bias and lack of awareness for the uncertain nature of the subject is grating, and could actively mislead readers.

If a neuroscientist wrote that physicists could control mass purely because they've uncovered the Higgs Boson, this would be unacceptable. But this book does that; it just switches the subjects around. 

DEAN BURNETT is a doctor of neuroscience and stand-up comedian



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# EASTER BOOKSHELF

Indulge your passion for literature this Easter, with these selected books

### **QUANTUM SOULS**

(THE CLEANSING)

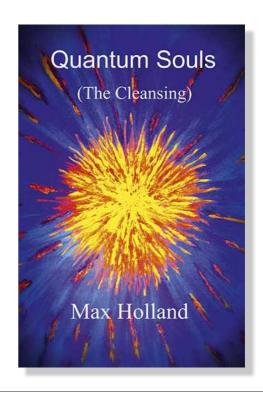
MAX HOLLAND

Paperback ISBN: 978-1-49213-210-3

Our DNA code is the intricate structure that ultimately designs us and there is little difference between single cell organisms and complex animals like humans. The world of quantum physics tells us there is nothing here except atoms. Are we just that, a single atom of intelligence in a Universe of atoms? So were we created in a different dimension, is life just a virtual reality game?

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# **PALEOFANTASY:** WHAT EVOLUTION REALLY TELLS US ABOUT SEX, DIET, AND HOW WE LIVE | MARLENE ZUK

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-Summer Books, Nature

# LETTERS TO A YOUNG SCIENTIST | EDWARD O. WILSON

Distilling sixty years of teaching into a book for students, young and old, Edward O. Wilson threads twenty-one letters with autobiographical anecdotes that illuminate his career and his motivations for becoming a biologist.

Appealing and inspiring... —Times Higher Education

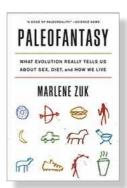
# **THE BONOBO AND THE ATHEIST:** IN SEARCH OF HUMANISM AMONG THE PRIMATES | FRANS DE WAAL

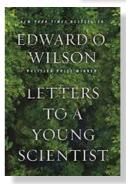
Bringing together his pioneering research on primate behaviour, the latest findings in evolutionary biology and insights from moral philosophy, Frans de Waal offers an illuminating new perspective on human nature.

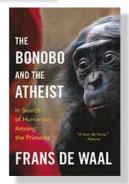
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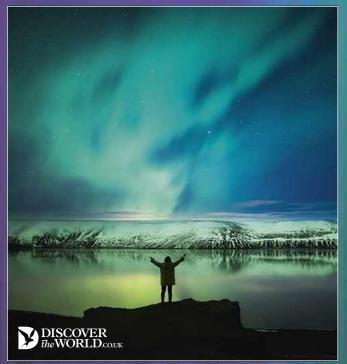






# THE NORTHERN LIGHTS

The Northern Lights are one of nature's great displays; a mysterious, multicoloured show in which the night sky is spectacularly lit up with a wondrous glow that twists and swirls. It's one of the great, timeless thrills of travel, a beautiful dance of natural light that many viewers find a humbling and spiritually uplifting experience.



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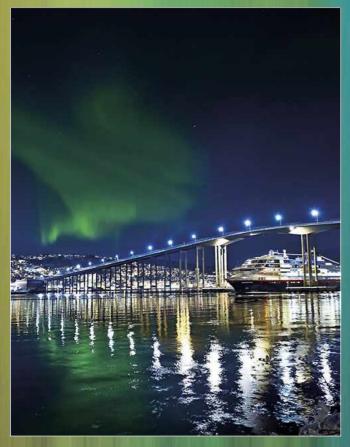


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# HURTIGRUTEN NORTHERN LIGHTS VOYAGE

SINCE 1893, HURTIGRUTEN HAS BEEN IMPOSSIBLE TO REPLACE - IMPOSSIBLE TO COPY

When the Norwegian government decided to create a connection between the north and the south, Richard With and his friend Anders Holthe took on the challenge of mapping the seas along the coastline. In 1893, Captain Richard With's steamer, DS Vesteraalen, was brought into regular service, and Hurtigruten was established.

In a coastal nation characterised by high mountains and long fjords, the sea offered the only way to tie the land together. Hurtigruten represented a communication revolution along the Norwegian coast.

120 years later, Hurtigruten still carry freight and passengers. Their captains use their extensive maritime expertise ensuring all are safely carried from port to port. Today, as then, the Hurtigruten ships are a part of Norwegian coastal life.

### **HURTIGRUTEN NORTHERN LIGHTS VOYAGE**

25TH January 2014 - MS Nordnorge

"We met our Hurtigruten coach outside the airport and enjoyed a short journey to the ship. After dropping off our luggage we went for a walk to the UNESCO Bryggen District of Bergen.

Hurtigruten have a ship leaving Bergen on this trip daily, providing an essential service to many Islands and coastal towns, calling at 34 ports sailing north and the same on the return trip south.

As we travelled north the days became noticeably shorter, the scenery changed daily, frequently spectacular with much more snow. There were numerous excursion opportunities and the ones we enjoyed most were:

- Trondheim Cathedral
- Dog sledding in Tromso
- The North Cape
- The Snow Hotel Kirkenes

The trip overall was a great success. Breakfast and lunch is plentiful, dinner is two sittings, a three course served meal. The whole purpose of our trip was to try and see the Northern Lights and our luck was in. We had four nights of the Lights, three of which were long lasting and spectacular. The crew were superb; nothing seemed to be too much trouble. Eskild our Tour Leader was outstanding and his excursion organisation faultless.

All that remains is for us to return in the summer to see the 'Midnight Sun'." **Peter and Pat Beadles** 

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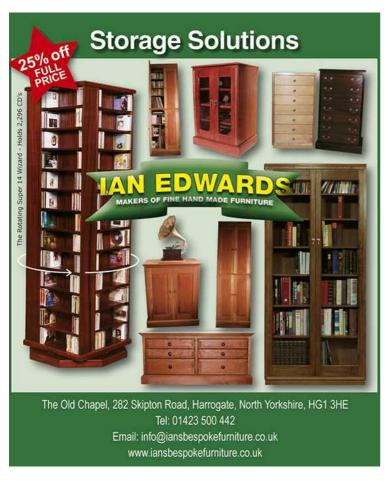


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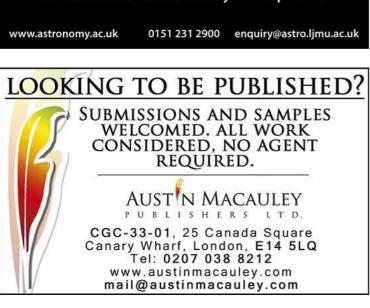
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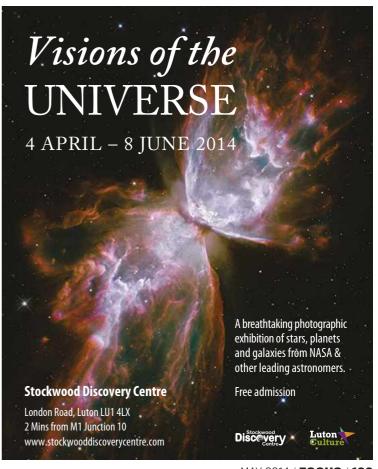
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FOUR

Don't miss *Only Connect*, a brain-bending quiz hosted by Victoria Coren on BBC

Four - see radiotimes.com for details

- Why have researchers in Hungary been putting dogs inside MRI scanners?
  - a) To discover which part of a dog's brain controls barking
  - b) To find out whether dogs are able to dream
  - c) To investigate how their brains respond to human voices
- 2 Scientists have named an acnecausing bacterium after which eccentric musician?
  - a) Syd Barrett
  - b) Prince
  - c) Frank Zappa
- The 2013/2014 winter was the UK's wettest on record. Which country received the most rainfall?

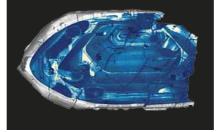
•••••

- a) Scotland
- b) Wales
- c) England
- What is shown in this image?
  - a) A creek in Australia seen from space
     b) The bronchioles of a bronchitis
     sufferer

c) A computer simulation of a plasma fractal



- This crystal from Western
  Australia is the oldest scrap
  of Earth's crust ever found.
  How old is it?
  - a) 2.4 billion years
  - b) 3.4 billion years
  - c) 4.4 billion years

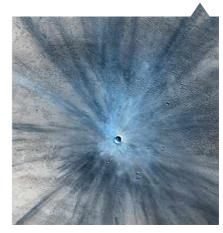


- Complete the recent headline:
  "Strange state of matter found in
  - a) Chameleon's tongue
  - b) Chicken's eye
  - c) Camel's hump
- What is the name of the recently confirmed ESA space observatory that's scheduled to launch by 2024?
  - a) PLATO
  - b) SOCRATES
  - c) ARISTOTLE
- What type of animal, called Lydia, was recently reported to be crossing the Atlantic towards the UK?

••••••

- a) Killer whale
- b) Salt water crocodile
- c) Great white shark
- When its kin are distressed, which animal has been found to offer comfort?
  - a) Flamingo
  - b) Elephant
  - c) Honeybee

- According to a new study, what might be an effective way to tame Atlantic hurricanes?
  - a) Using a vast offshore wind farm to sap the hurricane's power
  - b) Dragging a city-sized ice cube over the ocean to cool it down
  - c) Using infrasonic sound waves to destabilise the developing cyclone
- What's the name of a newly discovered 'quasiparticle' that acts like a liquid?
  - a) Flopleton
  - b) Dropleton
  - c) Grumpleton
- Complete the recent headline: "New Hyundai vehicle fuelled by \_\_\_\_\_"
  - a) Poo
  - b) Custard
  - c) Air
- This spectacular impact crater, photographed by a NASA spacecraft, recently appeared on which planet?
  - a) Mercury
  - b) Venus
  - c) Mars



**TURN OVER FOR ANSWERS** 

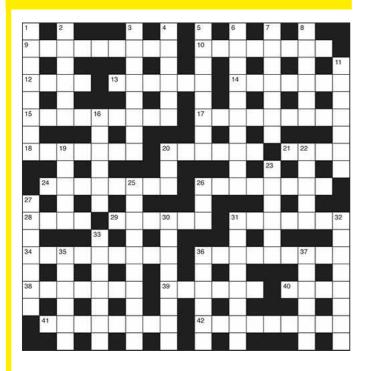
**OUIZ ANSWERS** 

Jc, 2c, 3b, 4a, 5c, 6b, 7a, 8c, 9b, 10a, 11b, 12a, 13c

**HOW DID YOU SCORE?** 

BARKING UP THE WRONG TREE 5-9 LIFE IN THE OLD DOG YET 10-13 TOP DOG

# FOCUS CROSSWORD No 163



# **ACROSS**

- The spirit of mercury, say (9)
- 10 Glacial formation found on cold bed (3.5)
- 12 The burden we bear (4)
- 13 Policeman surrounds old fashionable launderette (4-2)
- Article more about a proposition (7)
- 15 One cinder affected a gland (9)
- Arachnid becomes an administrator (9)
- 18 Attempts to reach the borders of a port (7)
- 20 Wind round the French fabric (6)
- 21 Only with a twitch of the ears (4)
- 24 Pine away in part of house in capital (8)
- 26 Rate a mug embellished with a flower (8)
- 28 Industrial area union by harbour between rivers (4)
- 29 A gull managed to point to missing water (6)
- 31 Gable fashioned by artist using numbers (7)
- 34 Firm now acquires new church rationality (9)
- 36 Car award not finishing at selfsustaining plant (9)
- 38 Weapon with foil arrangement like a wing (7)
- **39** Put me to work with iodine while computer is running (6)
- 40 Register a fish (4)

**YOUR DETAILS** 

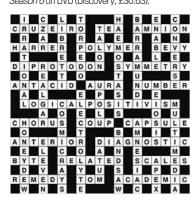
- 41 Some cooked fish with a bit of fruit (8)
- 42 Quiet look around house with viscount and writer (9)

### DOWN

- Clear the way after Fred's toe got broken (8)
- Productive combination of iron,
- copper and neodymium (6)
- A protein turned into a toxin (8)
- Fellow angel adjusted collar (6)
- RAF capability used by wind turbines (3.5)
- 6 Man, say, to organise rave better (10)
- Feline shark, say (7)
- Search for a polecat (6)
- Air came tumbling onto land (7)
- So nice, planning function (6)
- 19 Nationality of woman and husband (5)
- 20 Insect causes a technical issue (3)
- 22 Digit with its own rule (5)
- 23 Three keys to acquire for device (6)
- 25 Expression for playing mainly polo (10)
- A copy of the paper (3)
- Recurring pattern involving rat and calf (7)
- **30** Routes are a joke in front of Peruvian city (8)
- Mountain formation? It's elementary (8)
- 32 Glue to hide vase's breakage (8)
- 33 Chromium worked loose with oily liauid (7)
- 35 That woman has energy, if she's a youngster (6)
- 36 I must improve after a disorder (6)
- 37 Alternatively cultivate each vegetable

# **SOLUTION TO CROSSWORD No 160**

Steve Millard, Danny Langton, Peter Haworth, R Beckett and Glenys Robinson each solved issue 264's puzzle and receive a copy of MythBusters Season 6 on DVD (Discovery, £30.63).



### WINI **CARL SAGAN'S COSMOS**

The first five correct solutions drawn will each win a copy of Carl Sagan's Cosmos (Fremantle Home Entertainment, £10.47). Entries must be received by 5pm on 1 May 2014, See below for more COSMO details.

# **POSTCODE EMAIL**

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Post entries to BBC Focus Magazine, May 2014 Crossword, PO Box 501, Leicester, LE94 0AA or email a scan of the completed crossword or a list of answers to may 2014@focuscomps.co.uk by 5pm on 1 May 2014. Entrants must supply name, address and phone number. Immediate Media, publisher of BBC Focus Magazine, may contact you with details of our products and services or to undertake research. Please write 'Do Not Contact' on your email or postal entry if you do not want to receive such information by post or phone. Please write your email address on your postal entry if you would like to receive such information by email.

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# THE DOUBLE

THEY SAY WE'VE all got one, though few of us have ever seen it. No, not your anus but your doppelgänger – a person that looks so like you that you'd swear you were looking in a mirror. In director Richard Ayoade's new film, *The Double*, a timid office-worker comes face to face with his more confident lookalike. Surreal hilarity ensues. But how likely are you to encounter your double?

Suppose there is someone that looks like you. With over 7 billion people in the world, you're more likely to collide with space debris than you are with them. But suppose, for a second, that you do. There are four possibilities to explain the encounter.

First, recombination has randomly shuffled the 3 billion letters of your genetic code to produce a genuine doppelgänger. You're not related, just freakishly alike. Go forth and buy a lottery ticket – your luck is in.

Second, your mind is playing tricks on you. Although rare, people with epilepsy or schizophrenia sometimes hallucinate convincing body doubles. Dostoyevsky himself, on whose 1846 novella the film is

# "People with epilepsy or schizophrenia can hallucinate body doubles"

based and who suffered from epilepsy, is thought to have experienced this so-called 'whole body illusion'. Electrical stimulation of a brain region implicated in the creation of 'the self' - the left temporoparietal junction - can produce a similar effect. Stay away from scientists with electrodes.

Third, it's premeditated plastic surgery. Perhaps you have a fan that wants to look like you, like Justin Bieber. A 33-year-old, Toby Sheldon, reportedly had several operations to look like the spaniel-faced crooner. It may be the sincerest form of flattery, but consider going ex-directory.

Last, it's an identical twin you never knew you had. After the inevitable double take, consider, how much like you would they really be? Identical twins may look alike, but they're not physically or mentally identical. "People tend to emphasise their similarities and overlook their differences," says twin researcher Jeff Craig from Australia's Murdoch Childrens Research



Institute: Identical twins can be subtly different heights and builds, and can have different hair or eye colour. Physical attributes are heavily influenced by genetics but, contrary to popular belief, identical twins don't always carry identical DNA. Just like the rest of us they can be born with, or pick up, genetic mutations through life. Craig has also found differences in the patterns of chemical switches that control gene activity. "We can spot these epigenetic changes as early as 32 weeks, which means that identical twins are already different when they are in the womb," he says. If identical twins are raised apart, their genetic and epigenetic codes will shape an individual that is unique. So if you do

meet your doppelgänger, don't expect them to share your

expect them to share your penchant for naked Zumba. 

HELEN PILCHER is a science writer and comedian. She tweets from @helenpilcher1







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**DRIVE ABARTH RESPONSIBLY** 

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Abarth 595 Turismo and Competizione fuel cons mpg (I/100km): urban 33.2 (8.5) / extra-urban 52.3 (5.4) / combined 43.5 (6.5), CO2 emissions: 155g/km. Abarth 500C fuel cons mpg (I/100km): urban 33.6 (8.4) / extra-urban 52.3 (5.4) / combined 43.5 (6.5), CO2 emissions: 151g/km. The new Abarth 500 range starts from £14,255 OTR. Models shown: Abarth 595 Tursimo (at £18,905 On The Road) including optional Bi-Colour paint (£950), Abarth 595 Competizione (at £19,355 On The Road) including optional Record Grey Paint (£400) and Abarth 500C (at £16,818 On The Road) including optional Side Stripe & Door Mirrors (£163), optional 17" Alloy wheels (£300) and optional Gara White Paint (£300). ABARTH WITH

Promotion available on new Abarth models registered before 30th June 2014. With Advance Payment Plan you have the option to return the vehicle and not pay the final payment, subject to the vehicle not having exceeded an agreed annual mileage (a charge of 6p per mile for exceeding 10,000 miles per annum in this example) and being in good condition. \*Deposit amount is typically between 50% to 60% depending on term, model, and mileage. Finance subject to status. Guarantees may be required. Abarth Financial Services, PO BOX 4465, Slough SL1 0RW. Fuel consumption and CO2 figures based on standard EU tests for comparative purposes and may not reflect real driving results.

